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Volume 7, Number 10 October 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

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Reports

DIGEST OF PROTECTION STANDARDS AND STATE REGULATIONS FOR RADIOACTIVITY IN WATER

J. L. S. Hickey[1]

Numerical limits of seven published standards and guides for radium-226, strontium-90, and unidentified radionuclides in water for various applications and population groups are summarized. Of the 54 States and Territories, 47 have legislation or regulations for control of radionuclides in water. Of these, 31 have adopted some form of numerical limits for control of radionuclides in water. Sixteen States and Territories have general legislation permitting control of radiation exposure but no numerical limits for radionuclides in water, and seven have no specific legislation for control of radionuclides in water.

At least seven International and National agencies publish standards, recommendations, or guides for radionuclides in water. Although Tsivoglou and Burke (*1*) have found no basic conflict among these standards and guides, extensive study of several technical publications is required to reconcile differences in the numerical values given.

A listing of the published guides and limits for the radionuclides commonly found in water supplies and sources, as well as a summary of the regulations adopted by the States for these radionuclides in water, has been prepared for use as a reference by public health field personnel responsible for the radiological quality of drinking water and water sources.

The numerical guides and limits which are to be discussed have a variety of applications, and each must be considered on the basis of its intended application as well as on the basis of the numerical values given.

Radium-226 and strontium-90, because of biological uptake and retention in critical organs, long life, and energetic radiation, are two of the most important radionuclides found in water. Radium-226 is found naturally in some well waters, and strontium-90 is found in surface waters as a result of fallout. This report discusses these nuclides and also unidentified radionuclides. Unidentified radionuclides are included because measurements of gross radioactivity in water are relatively simple screening procedures which can be used to reduce the workload when the volume of samples is large and little radioactivity is anticipated.

Published standards and recommendations

Table 1 lists recommended upper limits for radium-226, strontium-90, and unidentified radionuclides in water, in some cases exclusive of natural background. The values applied to the general population are somewhat lower than the recommended limits of exposure for individuals and for populations near a nuclear facility. Although some values appear several times, the reader should not infer that the median or most frequently occurring numerical values are necessarily the most desirable limits.

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Various facets of these limits are discussed in the following text, with emphasis on application to the general population. In these discussions, the agencies are referred to by the initials shown in table 1, and the references are those in table 1 except where indicated otherwise.

Point of application of limits: The values shown in table 1 are intended to establish limits for human exposure to radioactive materials, and several of the recommendations apply at the point of human intake. However, the Atomic Energy Commission (AEC) regulations, the Council of State Governments (CSG) recommendations, and the National Committee on Radiation Protection (NCRP) suggested radiation protection regulations generally pursue this objective by limiting the radioactivity levels in effluents discharged into unrestricted areas.

These three agencies permit discharge of radioactivity in excess of the limits shown in table 1 if it can be demonstrated that human exposure limits will not be exceeded. They also provide for more stringent limits on effluents discharged to unrestricted areas where circumstances warrant; for example, if several installations discharging radionuclides to the same stream resulted in possible human exposure above the recommended limits.

FRC recommendations: The Federal Radiation Council (FCR) guidance for intake of radionuclides is different from the others in that it is based on total daily intake from all sources except natural background. The intake guides recommended by the FRC cover three broad ranges. The FRC recommends that "routine control of useful applications of radiation and atomic energy should be such that expected average exposures of suitable samples of an exposed population group will not exceed the upper value of Range II." These values are 20 pCi/day for radium-226 and 200 pCi/day for strontium-90. The limits per liter shown in table 1 for the FRC were derived from the above

Table 1. Summary of standards and guides for radium-226, strontium-90, and unidentified radionuclides in water

Point of nuclide measurement	Agency (and reference number)	Applicable population group	Upper-limit, pCi/liter		
			Radium-226	Strontium-90	Unidentified
At point of human ingestion (drinking water system)	International Commission on Radiological Protection (ICRP) (*2, 3*)	Any individual	10	400	10
	National Committee on Radiation Protection; Suggested Radiation Protection Regs. (*4*)		10	100	—
	U.S. Public Health Service Drinking Water Standards (PHS) (*6*)	General population	3	10	—
	World Health Organization (WHO) (*8*)		10	30	—
	ICRP (*2, 3*)		3.3	133	3.3
	ICRP (*2, 3*)	Population near a nuclear facility	10	400	10
	National Committee on Radiation Protection (NCRP) (*10*)		10	100	10
Assay of reasonable aliquot of total intake	Federal Radiation Council (FRC) (*7*)	Suitable sample of an exposed population group	[a] 9	[a] 90	—
In effluent water at point of discharge to unrestricted areas	U.S. Atomic Energy Commission (AEC) (*5*)	Any individual [b]	30	300	30
	Council of State Governments: Suggested State Regulations for Control of Radiation, April 1966 Revision (CSG) (*9*)		30	300	30
	CSG—1964 Edition (*11*)		10	100	10
	NCRP Suggested Radiation Protection Regs. (*4*)		10	100	—
Annual average intake measured at point of ingestion	AEC (*5*)	Suitable sample of exposed population [c]	10	100	10
	CSG—1966 Revision (*9*)		10	100	10

[a] Derived from FRC guides for total intake per day of 20 pCi of ^{226}Ra and 200 pCi of ^{90}Sr, assuming a dietary intake of 2,200 g/day total water and food (*2*), containing equal concentrations of these radionuclides, and no other radiation exposure above that from natural background.

[b] Discharge limits may be raised if no individual is thus exposed to radioactivity levels in water greater than limits shown.

[c] Discharge limits may be lowered if necessary to prevent exposure of the population to radioactive intake greater than the intake resulting from continuous exposure to water containing the concentrations shown.

values assuming a daily intake of 2,200 grams of water and food (*2*) containing equal concentrations of these radionuclides and no other radiation exposure above that from natural background.

Application of guides: AEC regulations are binding on their licensees. Public Health Service (PHS) Drinking Water Standards are binding on interstate carriers and others subject to Federal quarantine regulations. The FRC develops Federal policy on human radiation exposure consistent with an orderly development of the application of nuclear energy and ionizing radiation. A major function of the FRC is to guide "all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with States" (*12*). The other published limits shown in table 1 are recommendations of each organization.

Radioactivity in water in relation to total exposure: Values given by the International Commission on Radiological Protection (ICRP), NCRP, AEC, FRC, and CSG for limiting exposure to radioactivity from drinking water apply, either expressly or by implication, where there is no other significant source of internal radiation exposure, such as from air or food above that received from natural background. A formula has been adopted by some of the agencies for reducing limits in cases of exposure from more than one radionuclide. Under this formula, the sum of the concentrations of all radionuclides taken internally, each divided by its own limit, may not exceed the value of one (unity).

The World Health Organization (WHO) and PHS standards for drinking water allow for additional radiation exposure from other sources, such as from air and food. They should therefore be considered as guidance levels rather than as upper limits. The PHS standards are formulated on the basis that if these levels are not exceeded, water supplies shall be approved without further consideration of other sources of intake of these radionuclides. The PHS standards also state that "when these concentrations (*i.e.*, 3 pCi/liter of radium-226 and 10 pCi/liter of strontium-90) are exceeded, a water supply shall be approved by the certifying authority if surveillance of total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by the Federal Radiation Council for control action" (*6*). These limits are 20 pCi/day for radium-226 and 200 pCi/day for strontium-90 above that received from natural background (*7*).

The WHO limits in table 1 should also be interpreted as levels which "are merely intended to indicate that, if the levels are lower than those given, then the water is safe for use without further investigation" (*8*).

Natural background: The limits in table 1 for AEC, NCRP, CSG, ICRP, and FRC are for exposure above "natural background" and therefore could be interpreted as not applying to naturally occurring radioactivity in water in any amount. This presents a situation in which the judgment of persons responsible for the radiological quality of drinking water could play a large role in the application of the guides —as in determining whether, for example, 20 pCi/liter of naturally occurring radium-226 in a well water supply should be classed as natural background. ICRP specifies that its recommendations exclude background only when it is insignificant. The PHS and WHO recommended limits include internal exposure from naturally occurring radioactivity.

Soluble and insoluble nuclides: The limits given in table 1 for NCRP, ICRP, CSG, AEC, and NCRP suggested State regulations are for soluble radionuclides. Permissible limits for insoluble radionuclides range up to 3,000 times higher for radium-226 and up to 400 times higher for strontium-90, reflecting a smaller probability of assimilating the radionuclides when in the insoluble state. WHO, PHS, and FRC limits do not specify the soluble or insoluble state.

Unidentified radionuclides: The limits for unidentified radionuclides in water generally coincide with those for soluble radium-226. This in effect means that any unidentified radionuclide is presumed to be soluble radium-226, which has a lower allowable limit than any

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other nuclide in water. Where total radioactivity in water is very low, gross radiation counts can be used to demonstrate this, and make more detailed analyses unnecessary.

Discharge to sanitary sewers: AEC and CSG standards for radionuclide levels in wastes discharged directly to sanitary sewers are given in table 2. These are from 40 to 100 times higher than the limits in table 1. AEC and CSG standards specifically exempt wastes discharged to sanitary sewers from the limits placed on other effluents discharged to unrestricted areas. Instead, the average monthly radionuclide concentrations in the total sanitary sewer flow leaving a licensee's installation are limited to the values in table 2.[2] Sufficient additional dilution of these wastes will ordinarily occur before they are capable of exposing the public, such as by contamination of a stream used as a drinking water source. Because the extent of dilution will vary, there is a large area for judgment on the part of the responsible persons in applying these limits.

Table 2. Limits for discharge of soluble radium-226, strontium-90, and unidentified radionuclides into sanitary sewers [a]

Source of standard	Limit, pCi/liter		
	Radium-226	Strontium-90	Unidentified
U.S. Atomic Energy Commission Regulations (5)	400	10,000	400
Council of State Governments: Suggested State Regulations for Control of Radiation, 1966 (9)	400	10,000	400
Council of State Governments: Suggested State Regulations for Control of Radiation, 1964 Edition (11)	400	4,000	300

[a] Measured at point of leaving licensee's installation

Average sample values: In determining average radionuclide levels in drinking water for application of the guides and standards, all the agencies suggest that sample results be averaged over a 1-year period, except the ICRP, WHO, and NCRP suggested regulations which recommend quarterly averaging of samples.

State regulations

Table 3 summarizes State regulations on standards for radionuclides in water. Of the 54 States and Territories, 47 have specific legislation or regulations enabling them to control radioactivity in water. Of these, 31 have adopted some form of numerical limits for radionuclides in water, 16 do not have specific limits for radionuclides in water, and 7 have no specific legislation applicable to control of radiation exposure from water.

Thirteen States have adopted regulations similar to that recommended by the CSG (1964 edition). Seven have adopted NCRP recommendations as given in the National Bureau of Standards Handbook 69 by reference; of these, three specify "current" NCRP recommendations, and thus automatically update their standards to conform with new NCRP recommendations. Three States which specifically adopted either the 1957 AEC regulations or the NCRP recommendations in NBS Handbook 52 and 59 (*13,14*) still retain them.

Table 3. Summary of State regulations for control of exposure of the population to radioactivity in water

Number of States or Territories[a]	Type of regulations
13	Substantially same as Council of State Government 1964 recommendations
7	NCRP Standards: NBS Handbook 69
5	Substantially same as NCRP suggested radiation protection regulations
2	Current AEC standards adopted by reference
3	1957 AEC or NBS Handbooks 52 and 59 standards
1	AEC continuous occupational exposure standards reduced by factor of 10
16	General legislation to control exposure but no numerical standards
7	No specific applicable legislation

[a] Includes D. C., Puerto Rico, Guam, and Virgin Islands.
Sources: Atomic Energy Law Reports (*17*) and most recent State publications.

Interpretation of samples

In monitoring water supplies or sources for radioactivity, the basic health goal is to determine the radioactivity actually ingested by human beings. It is therefore important that samples be representative of the water consumed by the populace. Generally, treated water collected from representative locations may be composited over a 3-month period to obtain representative samples for radiological analysis.

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[2] In addition, AEC licensees are limited to a total discharge of 1 curie per year (10 CFR 20.303 b2d).

This is possible whenever the significant radionuclides have long half-lives. Since the radionuclide concentrations may vary within a distribution system, care must be taken in choosing sampling locations.

Analyses of raw water, either surface or ground, should be viewed in light of the type of treatment to be provided, as conventional or ion exchange treatment may remove as much as 95 percent of the contained radioactivity (*15*).

Considerations in setting of standards

The critical organ in the body for both radium-226 and strontium-90 is the skeleton. Experience with radiation damage to the human skeleton is largely limited to cases in which large amounts of radium (or thorium) were ingested by adults, through either occupational exposure or medication. This experience has played a large role in the development of standards for internal radiation exposure.

Since the several current standards and guides for radium-226 exposure from drinking water are substantially of the same magnitude, only one, the FRC standard, will be reviewed here for an understanding of the factors considered in establishing these standards and guides, and as a basis for estimating the factor of reduction built into the standards below that exposure from radium-226 in drinking water which might be expected to result in detectable damage to the body.

Based on experience with radium-226 damage, the NCRP set the maximum body burden for radium-226 at 0.1 μCi (*13*), a value which had been in use since 1941. The FRC (*7,12*) adopted 0.1 μCi of radium-226 in the skeleton as the radiation protection guide for radiation workers, noting that detectable skeletal damage had occurred in adults who had a residual radium body burden of 0.5 μCi. The upper limit of the FRC Range II transient rate of daily intake of 20 pCi/day was considered to be a dose which at equilibrium would result in a body burden not exceeding 1/100 of that permitted in radiation workers, or a body burden of 0.001 μCi of radium-226 for the average of a suitable sample of an exposed population group, or of 0.003 pCi for individuals in the general population.

Evans (*16*) points out that skeletal radium damage observed in humans has largely been due to radium-226 ingestion over a short period of time which resulted in a residual body burden of about 0.5 μCi, rather than due to chronic ingestion of small doses which eventually reached a body burden of about 0.5 μCi. He estimates that this results in a "silent safety factor" of 15 in the radiation protection guide for the radiation worker. This, combined with the factor of 100 mentioned previously, results in the FRC's guide for radium-226 exposure in the general population being 1,500 times lower than that which has been observed to lead to detectable skeletal damage.

This factor may, of course, not be fully applicable because of variations in population intake and the possibility of more subtle biological damage at lower body burdens of 0.1 nCi. Because of these uncertainties, all agencies publishing standards subscribe to the basic concept that radiation exposure to the populace be kept as low as possible, and that, in the words of the NCRP, "the goal should be no radioactive contamination of air and water and of the body if it can be accomplished with reasonable effort and expense" (*13*).

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PRECISION AND SENSITIVITY OF GAMMA SPECTROMETRIC MEASUREMENTS IN MILK

M. A. Wall and *A. S. Goldin*[1]

The sensitivity and precision of a gamma spectrometric laboratory for routine milk samples comprising four similar detector-analyzer systems was studied, utilizing the results obtained on environmental fluid milk samples. The sensitivity of the system was evaluated by measurements of iodine-131 concentrations, mostly at the zero counting level. The precision of the system was measured on the basis of replicate determinations of potassium and cesium-137 at higher counting levels.

At all levels studied, variability was not significantly different from that calculated from radioactivity statistics. Only at the highest level encountered was there any indication of a greater variability than would be expected on a statistical basis, and even at this level the difference was not significant at the 95-percent confidence level.

It is well established that the radioactive disintegration process occurs in a random manner in such a way that the number of disintegrations—and also the number of counts observed in a given period of time—vary in a way that is described by the Poisson distribution. This variation has been generally used as a basis for calculating the error of radionuclide determinations or, rather, that portion of the error attributable to "counting statistics."

In the laboratories of the Division of Radiological Health, as in many other laboratories, gamma spectrometry is used for the direct measurement of a number of nuclides in various media. In the general case, a gamma spectrum consists of a linear combination of nuclide spectra superimposed on a background spectrum.

Spectra must be mathematically analyzed in some way in order to determine the concentration of the gamma-emitting nuclides in the sample. At the Northeastern Radiological Health Laboratory, the spectra are analyzed by assigning to each nuclide a characteristic energy region, usually the region of the full-energy peak of one of its gamma photons, correcting for the contribution of other nuclides to this region, and then calculating the nuclide concentrations from calibration spectra.

As in any analytical procedure, it is important to know the precision, sensitivity, and accuracy of the method. This paper presents a method for the calculation of counting error and compares the actual precision, computed from replicate determinations, with the calculated counting errors at several levels. The determinations of iodine-131, cesium-137, and potassium in milk are used as examples.

Fundamentals

1. The number of counts N observed in a given counting period follows the Poisson distribution with mean $\bar{N}$ and variance $\bar{N}$.
2. The *gross* counting rate R_0 observed in a given counting period t_0 follows approximately a normal distribution with mean $\bar{R}_0$ and variance $\bar{R}_0/t_0$. The rate $\bar{R}_0$ is equal to N/t_0.
3. The *net* (gross minus background) counting rate R (where $R = R_0 - R_b$) follows approximately a normal distribution with mean $\bar{R}$ and variance $(R_0/t_0 + R_b/t_b)$. Here R_0 and R_b are the gross and background counting rates, respectively, observed over the times t_0 and t_b.

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[1] Mrs. Wall is a statistician and Dr. Goldin is deputy officer in charge at the Northeastern Radiological Health Laboratory, Division of Radiological Health, Public Health Service, Winchester, Massachusetts 01890.

The activity of each of the nuclides in milk can be analytically expressed (*1*) as:

$$^{131}\mathrm{I}:\ G_I = I + C_I C + L_I L + K_I K + B_I \quad (1)$$

$$^{137}\mathrm{Cs}:\ G_C = I_C I + C + L_C L + K_C K + B_C \quad (2)$$

$$^{140}\mathrm{Ba}:\ G_L = I_L I + C_L C + L + K_L K + B_L \quad (3)$$

$$^{40}\mathrm{K}:\ G_K = I_K I + C_K C + L_K L + K + B_K \quad (4)$$

The nomenclature for these equations is given below:

Item	Spectral region for			
	Potassium-40	Iodine-131	Cesium-137	Barium-140
Gross activity (cpm) in:	G_K	G_I	G_C	G_L
Background (cpm) in:	B_K	B_I	B_C	B_L
Fractional coefficient of potassium-40 in:	1	K_I	K_C	K_L
Fractional coefficient of iodine-131 in:	I_K	1	I_C	I_L
Fractional coefficient of cesium-137 in:	C_K	C_I	1	C_L
Fractional coefficient of barium-140 in:	L_K	L_I	L_C	1
Net activity (cpm) of each nuclide in its spectral region:	K	I	C	L

The net activities of each nuclide can then be expressed by equations of the form:[2]

$$I = a_I(G_I - B_I) + b_I(G_L - B_L) + c_I(G_C - B_C) + d_I(G_K - B_K) \quad (5)$$

which are obtained by the simultaneous solution of equations (1) to (4). At NERHL, the gamma spectra of 3.5-liter milk samples in Marinelli beakers are obtained with 4- by 4-inch NaI (thallium) crystals and 200-channel analyzers covering the range 0 to 2 MeV (10 keV per channel). Counting time is 50 minutes. The G's of equation (5) are obtained from these spectra. Backgrounds are measured by counting 3.5-liter samples of distilled water in the identical configuration, giving the B's of equation (5). The coefficients of equations (1) to (4) are obtained from gamma spectra of standard solutions of each nuclide, again in the same configuration.

The standard deviation of 1 (or of any other of the nuclide counting rates) is calculated from equation (5) by conventional propagation-of-error techniques, since all the G's and B's are statistically independent. In this treatment, the coefficients are treated as being without error. In fact, however, there is an error associated with these coefficients from statistical considerations and from differences in conditions between the "standard" runs and the "sample" runs. The statistical errors in the standards are reduced to negligible proportions by accumulating sufficient counts in each standard run. Other errors are minimized by controlling ambient conditions and sample volumes, and by maintaining precise control of the instrumentation.

In spite of these precautions, it is clear that there must be, at least in theory, differences in conditions from run to run. Some of the causes of these differences, without any attempt to be exhaustive, would include non-identity of sample breakers, non-identity of ambient conditions, change in crystal response or photomultiplier gain with time, and analyzer drift.

Sensitivity

The term sensitivity as used in the discussion refers to the minimum detectable activity which is defined as that measurement which is significantly greater than zero at the 95-percent confidence level. When defined in this way, it is equivalent to Altshuler's (*2*) "minimum significant measured activity."

The estimate of the variance, s^2, in a single measurement of the concentration of iodine–131 in a milk sample is

$$s^2 = a^2_I s^2_I + b^2_I s^2_L + c^2_I s^2_C + d^2_I s^2_K \quad (6)$$

where

$$s^2_I = \text{variance of } (G_I - B_I) = (G_I + B_I)t$$

with similar equations for the other s^2's. The counting time, t, is 50 minutes throughout, and s is in counts per minute.

The error in measuring a value for iodine–131 when the concentration was actually zero was calculated. In these calculations, a concentration of 1.5 grams of potassium per liter and various concentrations of cesium–137 and barium–140 was assumed. The calculations are

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[2] Where a, b, c, and d are constants for the specific nuclide.

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summarized in figure 1. It may be observed that the error is virtually independent of the cesium–137 concentration up to 100 pCi/liter, and is increased by less than 1 pCi/liter at cesium–137 concentrations up to 300 pCi/liter. Barium–140 has a greater effect on the error, but fortunately this nuclide is present in high concentrations in milk samples only when the iodine–131 content is also high.

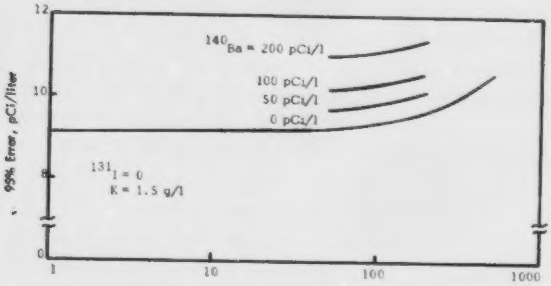

Figure 1. Calculated counting error for zero-level iodine–131

The measured iodine–131 contents of 94 milk samples analyzed during July 1963 are listed in table 1. During this time, the concentrations of barium–140, cesium–137, and potassium were, respectively, 0 pCi/liter, 95 to 410 pCi/liter, and approximately 1.5 g/liter. Since there was no atmospheric nuclear weapons testing during this time, the concentration of iodine–131 in these samples could be assumed to be zero. Figure 1 indicates that the error at the 95-percent confidence level for iodine–131 in these samples should be between 9.4 and 10.3 pCi/liter.

Table 1. Iodine-131 contents of 94 milk samples analyzed during July 1963, pCi/liter

1.4	−1.8	5.3	−7.1	−6.1
−8.6	−1.7	5.7	7.3	2.4
0.7	−1.0	−7.5	−1.3	2.2
−15.4	5.9	6.2	−0.2	4.1
3.6	4.1	−0.5	0.7	4.3
−7.0	0.1	3.0	−2.2	3.8
−7.5	3.4	−1.0	−0.1	−11.7
−0.3	3.2	1.9	−6.2	6.0
13.4	−3.7	1.1	−1.4	−7.0
3.0	−2.5	−4.8	5.5	2.4
−6.1	−4.8	−0.4	−6.3	−1.2
−9.1	−3.1	−9.7	0.9	−5.0
4.9	−6.2	−2.2	1.6	2.1
2.1	−3.4	1.6	17.6	−4.7
8.2	4.3	3.3	−2.7	1.1
−7.1	0.4	−1.6	−1.0	−6.0
7.3	−0.5	−2.0	−4.6	1.3
1.4	−1.1	2.8	3.1	−4.8
−1.4	0.2	−7.5	−2.1	

The 94 pieces of data of table 1 were used to test the following hypothesis: "the distribution of observed iodine–131 levels in milk, during this period, was normal with mean 0 pCi/liter and standard deviation 5 pCi/liter." The mean and standard deviation of the observed values were –0.5 and 5.2 pCi/liter, respectively. Application of the t and χ^2 tests (*3*) confirmed that these values were not significantly different from those of the hypothesis.

$$t=(\bar{x}-\mu)/\sigma_{\bar{x}}=\frac{(-0.5)-(0)}{5/\sqrt{94}}=-0.97;$$

$$P(|t|\leq .97)<70\% \qquad (7)$$

$$\chi^2=ns^2/\sigma^2=\frac{94(5.2)^2}{(5.0)^2}=101.67;$$

$$P(\chi^2\leq 101.67)<75\% \qquad (8)$$

For visual observation, the 94 values are presented as a graph on normal probability paper (figure 2), which indicates that the data are distributed normally. As a further check,

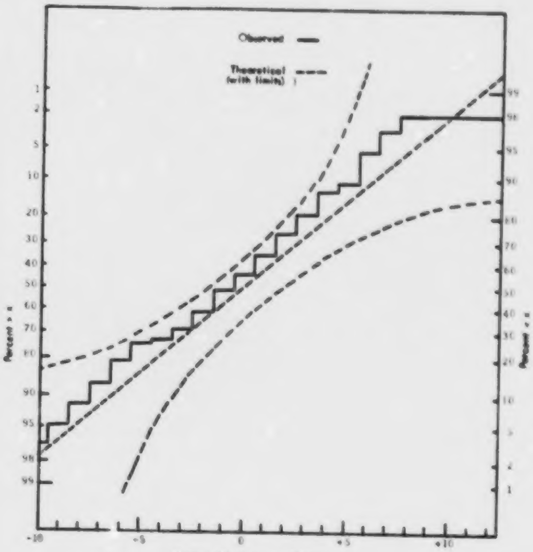

Figure 2. Cumulative frequency function, iodine-131 in milk, July 1963

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the goodness of fit to the normal line was tested by the Kolmogorov-Smirnov test (*4*). From all these tests, the hypothesis that the data are normally distributed with mean zero and standard deviation 5 pCi/liter can be accepted, leading to the conclusion that any result for iodine–131 greater than 10 pCi/liter is significantly different from zero at the 95-percent confidence level and that this is therefore the sensitivity of the determination.

In order to supplement the data on sensitivity obtained at an iodine–131 concentration of zero, samples containing small known quantities of iodine–131 in the presence of ordinary concentrations of cesium–137 and potassium were prepared and measured. The cesium–137 and potassium concentrations were 119 pCi/liter and approximately 1.6 g/liter, respectively. The sample was counted 10 times over a period of 2 weeks. The data are shown in figure 3. The known iodine–131 activity is shown as the straight line, indicating its exponential decay. It is obvious that the points are close to the known values, indicating that the accuracy at low levels for iodine–131 is acceptable.

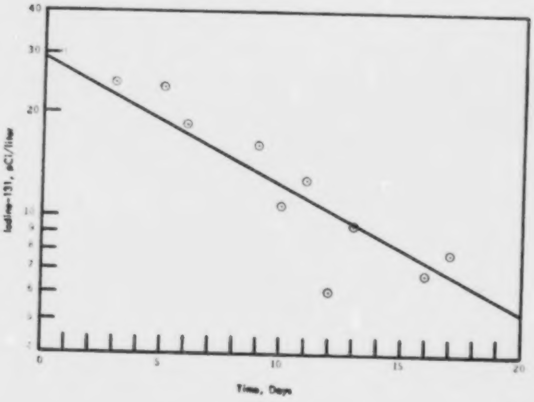

Figure 3. Low-level iodine–131 measurements

Precision

Most of the precision data were obtained from the average range of duplicate determinations which form the backbone of an internal quality control program. One out of five samples, taken randomly, is resubmitted to the counting room for gamma spectrometry as a "blind" duplicate: that is, it is submitted with a new number as a fresh sample. The data presented deal with values of potassium and cesium–137 which were the only gamma-emitting nuclides regularly present during the period November 1962 to November 1964.

Potassium. Although there is of course no radiological health interest in the potassium concentration of milk, it is necessary to correct for the contribution of potassium to the milk gamma spectrum. Accordingly, the potassium concentration is determined and in fact is used as a rough check on the spectrometry. Potassium content of milk ranges from about 1.4 to 1.8 g/liter, with an average around 1.5 g/liter.

The calculated counting standard deviation for the determination of potassium in solutions containing 1.5 g/liter of potassium, no iodine–131 nor barium–140, and 0 to 1,000 pCi/liter of cesium–137 is essentially constant at 0.065 g/liter.

This calculated standard deviation was compared with the observed standard deviation obtained from range measurements of 307 duplicate analyses. The mean range was found to be 0.0678 g/liter. The standard deviation corresponding to this mean range is 0.0601 g/liter. Confidence limits for the estimate of the standard deviation calculated from the mean range may be computed from the formula (*5*):

$$\frac{0.886\bar{R}}{1+z_{\alpha}\sqrt{0.571/n}}<\sigma<\frac{0.886\bar{R}}{1-z_{\alpha}\sqrt{0.571/n}} \qquad (9)$$

where

n = number of duplicate tests,
z_{α} = normal ordinate for confidence level α, and 0.886 and 0.571 are factors for sample sets of two observations.

The value of σ from equation (9), making the proper numerical substitutions, is between 0.0554 and 0.0656, in agreement with the value calculated from counting statistics. Therefore, at the level of 1.5 grams of potassium per liter of milk, the precision is controlled by counting statistics.

Cesium–137. A total of 458 sets of duplicate determinations of cesium–137 in milk were examined. The concentration in these samples varied from 50 to 500 pCi/liter. In order to perform the statistical analysis, the data were grouped according to concentration as shown in table 2. For each concentration the limits of the observed standard deviation, calculated from the range, were compared with the theoretical standard deviation based on counting statistics. The latter were calculated from the basic equation (6). The results of these analyses are depicted in figure 4. This graph shows that the observed data fall close to the theoretical line over the range 50 to 280 pCi/liter, with no trend from the theoretical. Even at the highest level, 280 to 480 pCi/liter, there is no significant increase over the theoretical error at the 95-percent [illegible] level. It is possible that at this [illegible] the counting error is only about 2 percent, measurement errors are becoming noticeable. Because of the small number of duplicate analyses at this level, it was not possible to investigate further.

Table 2. Comparison of theoretical and observed error in cesium-137 determinations

Cesium-137 (pCi/liter)	Midpoint (pCi/liter)	Number in group	Average range (pCi/liter)	Observed standard deviation (pCi/liter)	95-percent confidence level for standard deviation (pCi/liter)	Theoretical standard deviation (pCi/liter)
50–100	75	189	5.9	5.2	4.7–5.9	5.3
100–120	110	52	5.4	4.8	4.0–6.0	5.6
120–140	130	73	6.9	6.1	5.2–7.4	5.7
140–160	150	44	7.4	6.6	5.4–8.5	5.8
160–180	170	38	7.2	6.4	5.1–8.4	6.0
180–200	190	14	8.9	7.9	5.7–13.1	6.1
200–220	210	11	6.8	6.0	4.2–10.9	6.3
220–240	230	7	6.3	5.6	3.4–12.7	6.4
240–260	250	11	7.1	6.3	4.3–11.4	6.5
260–280	270	5	6.6	5.8	3.5–17.3	6.6
280–480	380	14	10.8	9.6	6.9–15.8	7.3
	1,000					10.2

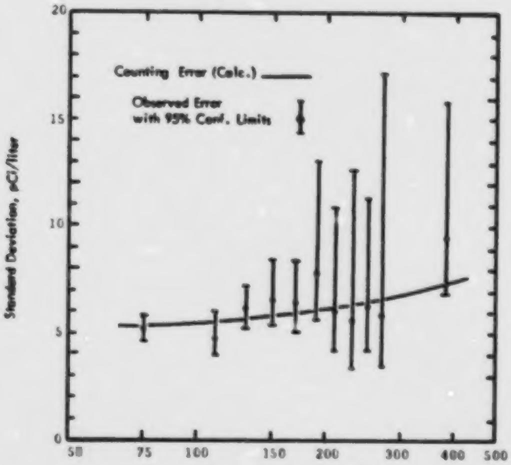

Figure 4. Calculated and observed errors in cesium–137 determinations

Conclusion

In the particular counting configuration described in this paper, which is in general use throughout the laboratories of the Division of Radiological Health, it has been found that the errors calculated from theoretical statistical considerations represent the total analytical error for milk samples containing radionuclides at environmental levels. The limits of precision and sensitivity for these measurements are, in fact, those which are calculated from the theoretical considerations. Assuming that adequate steps are taken to insure instrument stability (*i.e.*, daily calibration check with standard and daily background check), the precision of results obtained on a routine basis can be guaranteed.

Acknowledgment

The data used in this report were furnished by Mr. E. J. Baratta, director of the Analytical Services Program at this laboratory. The assistance of Mr. Robert Thompson is gratefully acknowledged.

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(*4*) MASSEY, F. J., JR. The Komogorov-Smirnov test for goodness of fit. J Am Stat Assn 46:68f (1951).

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ERRATUM. An erroneous statement appears in the report "Maine's Experience with a State-operated Personnel Monitoring Program for Radiation Workers," by J. W. Fuller (Radiol Health Data Rep 7:489–492, September 1966). The statement on page 490, "It was observed that beyond a 3-year period, the image on these film badges begins to fade; and after 5 years, the image had faded so badly that the value of the film as a record is very questionable" is incorrect. Actually, there was insignificant fading of the image on the majority of the film badges over the 10-year period.

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Data

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the United States population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; however, they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

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NATIONAL AND INTERNATIONAL SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk.

In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	July–December 1965	June 1966

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1. Pasteurized Milk Network
June 1966

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 issue of *Radiological Health Data* (1).

The results for June 1966 and for the second quarter of 1966 are presented in table 1. The average monthly radionuclide concentrations

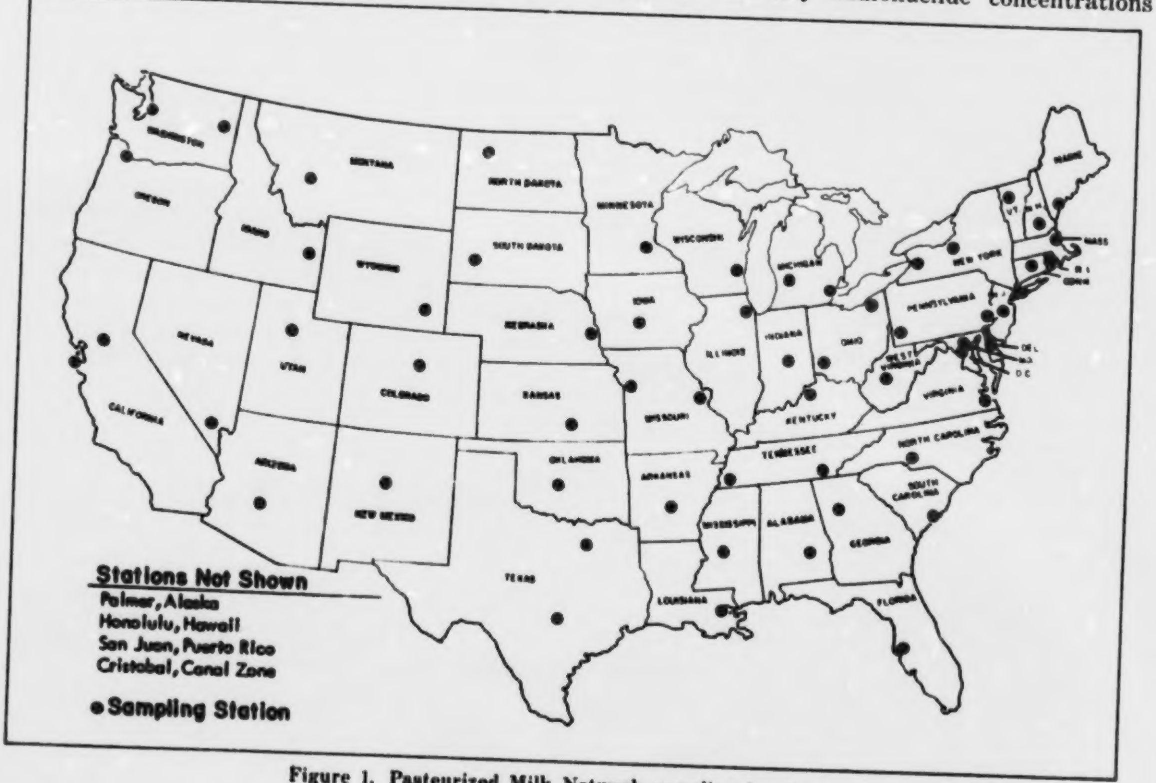

Figure 1. Pasteurized Milk Network sampling locations

Table 1. Average concentrations of radionuclides in pasteurized milk for the second quarter and June 1966 [a]

Sampling locations		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)		Barium-140 (pCi/liter)	
		Second quarter[b] 1966	June 1966	Second quarter 1966	June 1966	Second quarter 1966	June 1966	Second quarter 1966	June 1966	Second quarter 1966	June 1966
Ala:	Montgomery		10	12	12	25	25	10	10	0	0
Alaska:	Palmer		<5	15	17	40	35	0	0	0	0
Ariz:	Phoenix		<5	3	4	10	10	0	0	0	0
Ark:	Little Rock		35	32	31	40	40	40	30	10	20
Calif:	Sacramento		<5	9	8	15	15	0	0	0	0
	San Francisco		<5	9	7	20	15	0	0	0	0
C.Z:	Cristobal		5	4	4	20	20	0	0	0	0
Colo:	Denver		<5	11	11	25	25	0	0	0	0
Conn:	Hartford		5	13	15	40	40		0	0	0
Del:	Wilmington		5	17	16	40	30	0	0	0	0
D.C:	Washington		5	13	14	30	30	0	0	0	0
Fla:	Tampa		<5	10	10	125	135	0	10	0	0
Ga:	Atlanta		15	20	21	40	45	10	10	0	10
Hawaii:	Honolulu		<5	6	6	30	25	0	0	0	0
Idaho:	Idaho Falls		<5	14	12	40	35	0	0	0	0
Ill:	Chicago		<5	13	13	35	25	0	0	0	0
Ind:	Indianapolis		15	13	14	30	25	20	20	0	0
Iowa:	Des Moines		25	16	17	30	25	10	20	0	0
Kans:	Wichita		10	14	14	20	20	20	30	0	10
Ky:	Louisville		15	19	19	20	20	0	0	0	0
La:	New Orleans		10	32	34	45	50	0	10	0	0
Maine:	Portland		10	16	15	70	65	0	0	0	0
Md:	Baltimore		10	15	17	30	35	0	0	0	0
Mass:	Boston		5	17	20	60	60	0	0	0	0
Mich:	Detroit		<5	12	11	30	25	0	0	0	0
	Grand Rapids		<5	16	17	45	35	0	0	0	0
Minn:	Minneapolis		10	23	26	40	35	0	10	0	0
Miss:	Jackson		20	26	26	30	35	10	20	0	10
Mo:	Kansas City		35	17	19	25	25	30	30	0	10
	St. Louis		55	19	23	30	30	30	40	0	10
Mont:	Helena		<5	14	13	55	40	0	0	0	0
Nebr:	Omaha		20	15	17	30	25	10	20	0	0
Nev:	Las Vegas		<5	6	6	25	25	0	10	0	0
N.H:	Manchester		<5	17	18	80	85	0	0	0	0
N.J:	Trenton		<5	13	14	30	30	0	0	0	0
N. Mex:	Albuquerque		<5	6	6	20	20	0	20	0	0
N.Y:	Buffalo		<5	12	15	40	30	0	0	0	0
	New York		10	15	17	40	40	0	0	0	0
	Syracuse		<5	13	13	40	30	0	0	0	0
N.C:	Charlotte		15	20	21	30	35	20	20	0	0
N. Dak:	Minot		<5	34	31	40	35	0	0	0	0
Ohio:	Cincinnati		10	15	14	25	20	0	0	0	0
	Cleveland		5	14	14	35	25	0	0	0	0
Okla:	Oklahoma City		20	14	14	20	20	20	30	0	10
Ore:	Portland		<5	14	15	40	40	0	0	0	0
Pa:	Philadelphia		<5	14	14	35	30	0	0	0	0
	Pittsburgh		<5	19	21	45	40	0	0	0	0
P.R:	San Juan		<5	8	8	25	25	0	0	0	0
R.I:	Providence		<5	15	19	45	45	0	0	0	0
S.C:	Charleston		15	21	23	50	55	20	20	0	10
S. Dak:	Rapid City		<5	21	18	45	40	0	20	0	10
Tenn:	Chattanooga		10	21	22	30	30	0	0	0	10
	Memphis		15	19	19	20	20	20	20	0	10
Tex:	Austin		<5	6	6	15	15	0	10	0	0
	Dallas		15	16	15	25	20	20	20	0	10
Utah:	Salt Lake City		<5	12	12	35	35	0	10	0	0
Vt:	Burlington		5	14	15	50	40	0	0	0	0
Va:	Norfolk		10	16	17	30	30	0	0	0	0
Wash:	Seattle		<5	18	21	55	55	0	0	0	0
	Spokane		<5	18	18	40	40	0	10	0	0
W. Va:	Charleston		5	17	17	20	20	0	0	0	0
Wis:	Milwaukee		5	10	10	40	30	0	0	0	0
Wyo:	Laramie		<5	12	13	30	35	0	0	0	0
Network average			10	15.2	15.7	36	34	5	7	0	2

[a] Calcium analyses were discontinued as of March 1966.

[b] Quarterly averages are not reported since monthly averages for April were not calculated, as only 10 percent of the samples were analyzed for strontium-89.

are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value, except for iodine–131 and barium–140, where zero was used for averaging purposes.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for June 1965 and for January

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations June 1965 and January–June 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965	1966					
	June	Jan	Feb	Mar	Apr	May	June
Under 10	7	10	9	9	8	10	9
10–19	21	46	46	44	50	38	41
20–29	29	6	7	7	3	12	10
30–39	4	1	1	3	2	3	3
40–49	2	0	0	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations June 1965 and January–June 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965	1966					
	June	Jan	Feb	Mar	Apr	May	June
Under 50	19	57	56	56	55	51	56
50–99	38	5	6	6	7	11	6
100–149	5	1	1	1	1	1	1
150–199	1	0	0	0	0	0	0

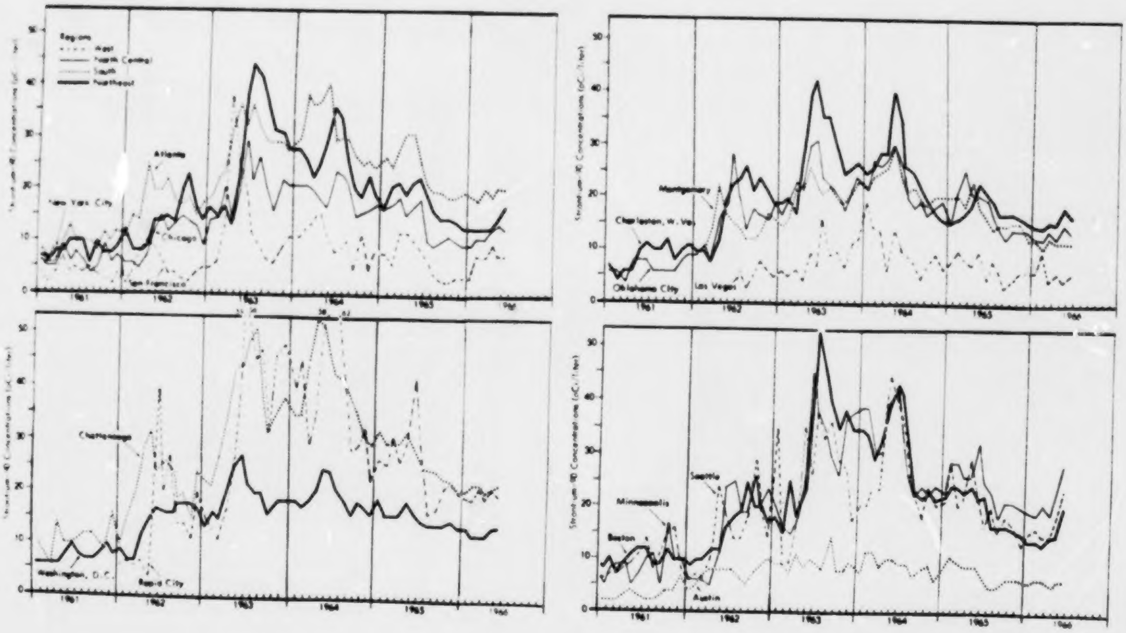

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961—June 1966

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Table 4. Daily iodine-131 concentrations in pasteurized milk, June 1966

Sampling location		Daily iodine-131 concentrations, pCi/liter																													
		June 1966																													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ala:	Montgomery		38							21				<10			<10				<10			<10							
Alaska:	Palmer			<10				<10																							
Ariz:	Phoenix			<10				<10			<10				<10			<10				<10			<10						
Ark:	Little Rock			9				48			38				<10			<10			<10				<10						
Calif:	Sacramento			<10					<10		<10				<10			<10													
	San Francisco			<10											<10		<10					<10			<10						
C.Z.:	Cristobal																														
Colo:	Denver			<10				<10			<10				10		<10					20			<10						
Conn:	Hartford			18				<10			<10				<10			<10				<10			<10						
Del:	Wilmington			29				13			<10				<10		<10					<10			<10						
D.C.:	Washington		14					10		<10					<10		<10														
Fla:	Tampa	47		18				18			<10			<10				<10				<10			13						
Ga:	Atlanta			49				20			14				<10			<10				<10			10						
Hawaii:	Honolulu			<10				<10			<10				<10			<10				<10			<10						
Idaho:	Idaho Falls			<10				<10			<10				20			<10				<10			<10						
Ill:	Chicago			1[illegible]				22		<10					<10		<10					<10		<10							
Ind:	Indianapolis			50			35				18			24				20			<10				<10						
Iowa:	Des Moines			40				30			30				30			20				<10			<10						
Kans:	Wichita			80				50			30				10			30													
Ky:	Louisville			20				13			<10				15			<10				<10		<10							
La:	New Orleans			45				25			<10				<10		<10					<10			17						
Maine:	Portland		<10				<10			<10				<10			<10				<10										
Md:	Baltimore			<10				<10			<10				<10							<10			14						
Mass:	Boston			<10				<10			<10				14		11					<10			<10						
Mich:	Detroit			<10				10			<10				13			10				<10									
	Grand Rapids	<10						<10			10				<10			18				<10									
Minn:	Minneapolis			<10				20			30				10			<10				<10			<10						
Miss:	Jackson							20			15				<10			20				<10			<10						
Mo:	Kansas City			40				30			50				40			20				10			<10						
	St. Louis						90			50				30			40				20			<10							
Mont:	Helena			<10				<10			<10				<10			20				<10			<10						
Nebr:	Omaha			70				20			<10				60			30													
Nev:	Las Vegas			40					20					<10				20					<10		<10						
N.H.:	Manchester	<10						<10			<10			<10			<10				<10				<10						
N.J.:	Trenton			<10					<10		<10				<10		<10					<10		<10							
N. Mex:	Albuquerque		<10				30				30			20				20			<10			<10							
N.Y.:	Buffalo			<10				<10			<10				<10			<10				<10			<10						
	New York			<10			<10			<10				<10			<10				<10			<10							
	Syracuse	14		<10				<10			<10				<10			<10				<10			<10						
N.C.:	Charlotte		37				27				17			17				<10			<10				17						
N. Dak:	Minot		<10				<10				20			<10			<10				<10			<10							
Ohio:	Cincinnati			19				<10		<10					11			<10				<10			<10						
	Cleveland	<10		<10				<10			14				<10			<10				<10			<10						
Okla:	Oklahoma City		97				57				25			25				14			17				13						
Ore:	Portland			<10				20			<10				<10			<10					<10			<10					
Pa:	Philadelphia			15				<10			<10											<10			<10						
	Pittsburgh	19		<10				<10			<10					<10		<10				<10		<10							
P.R.:	San Juan			2[illegible]				19			<10				<10			<10				<10			<10						
R.I.:	Providence			<10				<10			<10				<10			<10				<10			<10						
S.C.:	Charleston							19			<10				<10			<10				15			<10						
S. Dak:	Rapid City			<10			30				43				40			20				<10			50						
Tenn:	Chattanooga			22				11			<10				<10			<10				<10			<10						
	Memphis		61				29			15				12			<10				<10			<10							
Tex:	Austin			48				12			<10							11													
	Dallas		46				26			20				<10			<10				<10			<10							
Utah:	Salt Lake City			<10				20						<10				20				<10									
Vt.:	Burlington		<10				<10			<10					<10			12				<10									
Va:	Norfolk			18				12			<10				<10			11				<10			<10						
Wash:	Seattle			<10				<10			10				<10			<10				10			<10						
	Sookane			<10				20							<10			20				<10			<10						
W. Va:	Charleston			15				<10			<10				<10			<10				<10		<10							
Wis:	Milwaukee			13				13			13				<10			<10				<10			<10						
Wyo:	Laramie			<10				<10			<10				<10			<10				<10			<10						

through June 1966. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

In anticipation of an intrusion of iodine–131 levels to pasteurized milk, as a result of recently reported nuclear detonations (*2*), the sampling and analysis frequency for this radionuclide was increased to twice weekly as of May 16. The individual sample results for June 1966 are presented in table 4.

2. Canadian Milk Network
June 1966[1]

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*3*).

The June 1966 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine–131 concentrations were below minimum detectable levels.

Table 5. Stable elements and radionuclides in Canadian whole milk, June 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.13	1.5	12	20.8	33
Edmonton	1.08	1.6	6	17.8	44
Ft. William	1.11	1.6	12	26.1	69
Fredericton	1.10	1.6	2	28.1	58
Halifax	1.12	1.5	7	24.8	41
Montreal	1.11	1.6	6	16.5	40
Ottawa	1.12	1.6	8	12.1	34
Quebec	1.11	1.5	8	22.9	67
Regina	1.07	1.5	4	17.1	10
St. John's, Nfld	1.10	1.6	7	35.5	108
Saskatoon	1.11	1.6	2	21.1	22
Sault Ste. Marie	1.09	1.6	8	24.6	69
Toronto	1.13	1.5	5	11.0	33
Vancouver	1.14	1.6	4	22.1	91
Windsor	1.15	1.5	10	9.7	30
Winnipeg	1.10	1.6	28	15.3	47
Average	1.11	1.6	8	20.3	50

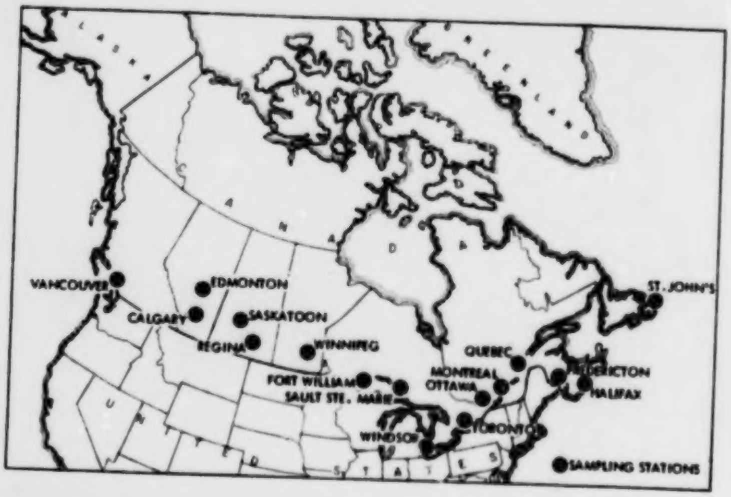

Figure 3. Canadian milk sampling stations

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[1] Prepared from July 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

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3. Pan American Milk Sampling Program June 1966

Pan American Health Organization and U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

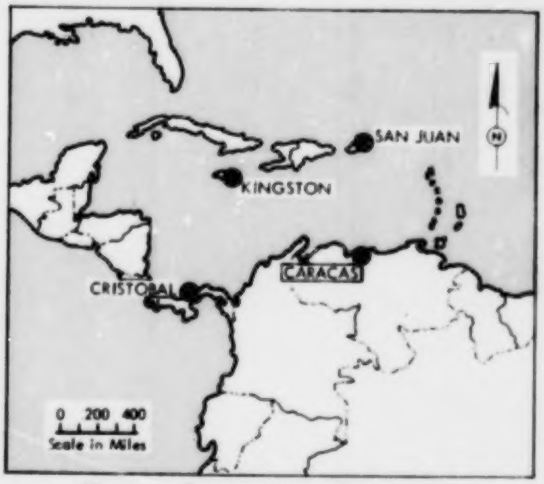

Figure 4. Pan American Milk Sampling Program stations

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*4*).

Table 6 presents stable calcium and potassium, strontium–90, strontium–89, and cesium–137 monthly average concentrations for June 1966. During this period, iodine–131 and barium–140 concentrations were below detectable levels.

Table 6. PAHO stable elements and radionuclide concentrations in milk, June 1966

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	NA	1.5	5	4	20
Jamaica:					
Kingston	NS	NS	NS	NS	NS
Mandeville	NS	NS	NS	NS	NS
Montego Bay	1.11	1.6	90	12	300
Puerto Rico:					
San Juan	NA	1.5	<5	8	25
Venezuela:					
Caracas	NS	NS	NS	NS	NS

NA, no analysis reported.
NS, no sample collected.

4. Annual Average Radionuclide Concentrations in Pasteurized Milk for the 12-Month Periods Ending September 1965 Through June 1966

Division of Radiological Health Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) program are reported on a monthly basis in *Radiological Health Data and Reports*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*5*) and permissible concentrations in selected environmental media (*6*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Tables 7 to 10 present annual averages of radionuclide concentrations in milk sampled by the PMN.[2] Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (7,8).

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[2] Annual averages for barium–140 at each station were <2 pCi/liter.

Table 7. Moving annual average strontium-89 concentrations in milk for 12-month periods starting October 1964 and ending February 1966 [a]

Sampling location		Average strontium-89 concentrations, pCi/liter					
		Oct 1964–Sept 1965	Nov 1964–Oct 1965	Dec 1964–Nov 1965	Jan 1965–Dec 1965	Feb 1965–Jan 1966	Mar 1955–Feb 1966
Ala:	Montgomery	3	3	3	3	3	3
Alaska:	Palmer	3	3	3	3	3	3
Ariz:	Phoenix	3	3	3	3	3	3
Ark:	Little Rock	5	4	4	4	4	4
Calif:	Sacramento	3	3	3	3	3	3
	San Francisco	3	3	3	3	3	3
C. Z:	Cristobal	3	3	3	3	3	3
Colo:	Denver	3	3	3	3	3	3
Conn:	Hartford	3	3	3	3	3	3
Del:	Wilmington	3	3	3	3	3	3
D. C:	Washington	3	3	3	3	3	3
Fla:	Tampa	3	3	3	3	3	3
Ga:	Atlanta	3	3	3	3	3	3
Hawaii:	Honolulu	3	3	3	3	3	3
Idaho:	Idaho Falls	3	3	3	3	3	3
Ill:	Chicago	3	3	3	3	3	3
Ind:	Indianapolis	3	3	3	3	3	3
Iowa:	Des Moines	4	4	4	4	4	4
Kans:	Wichita	3	3	3	3	3	3
Ky:	Louisville	4	4	4	4	4	4
La:	New Orleans	5	5	4	3	4	4
Maine:	Portland	3	3	3	3	3	3
Md:	Baltimore	3	3	3	3	3	3
Mass	Boston	3	3	3	3	3	3
Mich:	Detroit	3	3	3	3	3	3
	Grand Rapids	3	3	3	3	3	3
Minn:	Minneapolis	7	6	6	6	6	6
Miss:	Jackson	3	3	3	3	3	3
Mo:	Kansas City	5	5	5	5	5	5
	St. Louis	4	4	4	4	4	4
Mont:	Helena	3	3	3	3	3	3
Nebr:	Omaha	3	3	3	3	3	3
Nev:	Las Vegas	3	3	3	3	3	3
N. H:	Manchester	3	3	3	3	3	3
N. J:	Trenton	3	3	3	3	3	3
N. Mex:	Albuquerque	2	2	2	2	2	2
N. Y:	Buffalo	3	3	3	3	3	3
	New York	3	3	3	3	3	3
	Syracuse	3	3	3	3	3	3
N. C:	Charlotte	3	3	3	3	3	3
N. Dak:	Minot	6	6	6	6	6	6
Ohio:	Cincinnati	3	3	3	3	3	3
	Cleveland	4	4	4	4	4	4
Okla:	Oklahoma City	5	5	4	4	4	4
Ore:	Portland	3	3	3	3	3	3
Pa:	Philadelphia	3	3	3	3	3	3
	Pittsburgh	4	4	4	4	4	4
P. R:	San Juan	3	3	3	3	3	3
R. I:	Providence	3	3	3	3	3	3
S. C:	Charleston	3	3	3	3	3	3
S. Dak:	Rapid City	7	7	7	7	7	7
Tenn:	Chattanooga	4	4	4	3	3	3
	Memphis	4	4	4	4	4	4
Tex:	Austin	3	3	3	3	3	3
	Dallas	3	3	3	3	3	3
Utah:	Salt Lake City	3	3	3	3	3	3
Vt:	Burlington	3	3	3	3	3	3
Va:	Norfolk	4	3	3	3	3	3
Wash:	Seattle	3	3	3	3	3	3
	Spokane	3	3	3	3	3	3
W. Va:	Charleston	4	4	4	4	4	4
Wis:	Milwaukee	3	3	3	3	3	3
Wyo:	Laramie	3	3	3	3	3	3
Network average		3	3	2	3	3	3

[a] Strontium-89 analyses were discontinued in March 1966 except for a minimum of 10 percent of selected samples. Consequently, strontium-89 12-month averages will no longer be reported.

used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Tables 7 to 10 present annual averages of radionuclide concentrations in milk sampled by the PMN.[2] Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*7,8*).

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[2] Annual averages for barium-140 at each station were <2 pCi/liter.

Table 7. Moving annual average strontium-89 concentrations in milk for 12-month periods starting October 1964 and ending February 1966[a]

Sampling location		Average strontium-89 concentrations, pCi/liter					
		Oct 1964–Sept 1965	Nov 1964–Oct 1965	Dec 1964–Nov 1965	Jan 1965–Dec 1965	Feb 1965–Jan 1966	Mar 1965–Feb 1966
Ala:	Montgomery	3	3	3	3	3	3
Alaska:	Palmer	3	3	3	3	3	3
Ariz:	Phoenix	3	3	3	3	3	3
Ark:	Little Rock	5	4	4	4	4	4
Calif:	Sacramento	3	3	3	3	3	3
	San Francisco	3	3	3	3	3	3
C. Z:	Cristobal	3	3	3	3	3	3
Colo:	Denver	3	3	3	3	3	3
Conn:	Hartford	3	3	3	3	3	3
Del:	Wilmington	3	3	3	3	3	3
D. C:	Washington	3	3	3	3	3	3
Fla:	Tampa	3	3	3	3	3	3
Ga:	Atlanta	3	3	3	3	3	3
Hawaii:	Honolulu	3	3	3	3	3	3
Idaho:	Idaho Falls	3	3	3	3	3	3
Ill:	Chicago	3	3	3	3	3	3
Ind:	Indianapolis	3	3	3	3	3	3
Iowa:	Des Moines	4	4	4	4	4	4
Kans:	Wichita	3	3	3	3	3	3
Ky:	Louisville	4	4	4	4	4	4
La:	New Orleans	5	5	4	3	4	4
Maine:	Portland	3	3	3	3	3	3
Md:	Baltimore	3	3	3	3	3	3
Mass:	Boston	3	3	3	3	3	3
Mich:	Detroit	3	3	3	3	3	3
	Grand Rapids	3	3	3	3	3	3
Minn:	Minneapolis	7	6	6	6	6	6
Miss:	Jackson	3	3	3	3	3	3
Mo:	Kansas City	5	5	5	5	5	5
	St. Louis	4	4	4	4	4	4
Mont:	Helena	3	3	3	3	3	3
Nebr:	Omaha	3	3	3	3	3	3
Nev:	Las Vegas	3	3	3	3	3	3
N. H:	Manchester	3	3	3	3	3	3
N. J:	Trenton	3	3	3	3	3	3
N. Mex:	Albuquerque	2	2	2	2	2	2
N. Y:	Buffalo	3	3	3	3	3	3
	New York	3	3	3	3	3	3
	Syracuse	3	3	3	3	3	3
N. C:	Charlotte	3	3	3	3	3	3
N. Dak:	Minot	6	6	6	6	6	6
Ohio:	Cincinnati	3	3	3	3	3	3
	Cleveland	4	4	4	4	4	4
Okla:	Oklahoma City	5	5	4	4	4	4
Ore:	Portland	3	3	3	3	3	3
Pa:	Philadelphia	3	3	3	3	3	3
	Pittsburgh	4	4	4	4	4	4
P. R:	San Juan	3	3	3	3	3	3
R. I:	Providence	3	3	3	3	3	3
S. C:	Charleston	3	3	3	3	3	3
S. Dak:	Rapid City	7	7	7	7	7	7
Tenn:	Chattanooga	4	4	4	3	3	3
	Memphis	4	4	4	4	4	4
Tex:	Austin	3	3	3	3	3	3
	Dallas	3	3	3	3	3	3
Utah:	Salt Lake City	3	3	3	3	3	3
Vt:	Burlington	3	3	3	3	3	3
Va:	Norfolk	4	3	3	3	3	3
Wash:	Seattle	3	3	3	3	3	3
	Spokane	3	3	3	3	3	3
W. Va:	Charleston	4	4	4	4	4	4
Wis:	Milwaukee	3	3	3	3	3	3
Wyo:	Laramie	3	3	3	3	3	3
Network average		3	3	3	3	3	3

[a] Strontium-89 analyses were discontinued in March 1966 except for a minimum of 10 percent of selected samples. Consequently, strontium-89 12-month averages will no longer be reported.

Table 8. Moving annual average strontium-90 concentrations in milk for 12-month periods starting October 1964 and ending June 1966

Sampling location		Average strontium-90 concentrations, pCi/liter									
		Oct 1964–Sept 1965	Nov 1964–Oct 1965	Dec 1964–Nov 1965	Jan 1965–Dec 1965	Feb 1965–Jan 1966	Mar 1965–Feb 1966	Apr 1965–Mar 1966	May 1965–Apr 1966	June 1965–May 1966	July 1965–June 1966
Ala:	Montgomery	18	17	17	16	16	15	14	14	13	13
Alaska:	Palmer	18	17	17	17	16	16	16	15	15	15
Ariz:	Phoenix	5	5	5	5	5	4	4	5	4	4
Ark:	Little Rock	34	33	33	32	31	31	30	29	29	29
Calif:	Sacramento	6	6	6	6	6	6	6	6	6	6
	San Francisco	8	7	7	7	6	7	6	6	6	6
C.Z:	Cristobal	4	4	4	4	4	4	4	4	4	4
Colo:	Denver	17	16	16	16	15	15	14	13	13	12
Conn:	Hartford	16	15	14	14	14	13	13	13	12	12
Del:	Wilmington	18	18	18	17	17	17	16	16	16	15
D.C:	Washington	16	16	15	15	15	14	14	14	13	13
Fla:	Tampa	13	13	13	13	12	12	12	12	12	12
Ga:	Atlanta	25	24	24	24	23	22	22	21	20	20
Hawaii:	Honolulu	10	9	9	8	8	7	7	6	6	6
Idaho:	Idaho Falls	19	19	18	17	17	16	16	15	15	14
Ill:	Chicago	15	15	14	14	13	13	12	12	12	11
Ind:	Indianapolis	16	16	15	15	15	14	14	13	13	12
Iowa:	Des Moines	21	20	20	19	18	18	17	16	16	15
Kans:	Wichita	17	17	16	16	16	15	15	14	14	14
Ky:	Louisville	22	21	21	20	20	19	19	18	18	18
La:	New Orleans	39	38	38	37	36	35	33	32	31	31
Maine:	Portland	22	21	21	20	19	19	18	18	17	17
Md:	Baltimore	18	17	17	17	17	16	16	16	15	15
Mass:	Boston	22	21	21	20	19	19	18	17	16	16
Mich:	Detroit	15	14	14	13	13	13	12	12	11	11
	Grand Rapids	18	17	17	16	16	16	15	15	15	15
Minn:	Minneapolis	25	25	25	25	24	24	23	23	22	22
Miss:	Jackson	31	30	30	29	28	27	27	25	25	25
Mo:	Kansas City	21	20	20	19	19	19	18	17	17	17
	St. Louis	17	17	18	17	17	17	17	17	17	17
Mont:	Helena	18	18	18	18	17	17	17	16	16	15
Nebr:	Omaha	19	19	19	18	18	18	18	17	17	16
Nev:	Las Vegas	7	7	6	6	6	6	6	6	6	6
N.H:	Manchester	23	23	23	22	22	21	21	20	19	19
N.J:	Trenton	15	15	14	14	14	14	13	13	13	12
N. Mex:	Albuquerque	9	9	9	9	8	7	7	7	6	6
N.Y:	Buffalo	15	15	14	14	13	13	12	12	11	11
	New York	19	19	18	18	17	17	16	16	15	15
	Syracuse	15	15	15	14	14	13	13	13	12	12
N.C:	Charlotte	28	27	27	26	25	25	24	23	22	22
N. Dak:	Minot	45	44	44	42	40	39	37	35	33	32
Ohio:	Cincinnati	16	16	16	15	15	14	14	14	13	13
	Cleveland	17	16	16	16	15	15	15	14	13	13
Okla:	Oklahoma City	18	18	17	17	17	16	15	14	14	14
Ore:	Portland	20	19	18	17	17	16	15	15	14	13
Pa:	Philadelphia	16	16	16	15	15	14	14	14	13	13
	Pittsburgh	23	23	22	21	21	20	20	19	19	18
P.R:	San Juan	11	11	11	10	10	10	9	9	9	9
R.I:	Providence	18	18	18	17	17	16	16	15	15	14
S.C:	Charleston	27	27	27	26	26	25	25	24	23	23
S. Dak:	Rapid City	27	27	26	26	25	24	24	23	23	21
Tenn:	Chattanooga	30	29	28	27	26	25	25	24	23	22
	Memphis	24	23	23	22	22	21	20	19	19	18
Tex:	Austin	7	7	7	7	7	6	6	6	6	6
	Dallas	16	16	16	16	15	15	14	14	14	14
Utah:	Salt Lake City	20	20	19	19	18	16	16	15	13	12
Vt:	Burlington	20	19	19	18	18	17	17	16	16	15
Va:	Norfolk	15	14	14	13	13	12	12	11	11	11
Wash:	Seattle	22	22	21	21	20	19	19	18	17	17
	Spokane	23	23	22	22	21	20	19	18	17	17
W. Va:	Charleston	18	18	18	18	17	17	17	17	16	16
Wis:	Milwaukee	14	14	14	13	13	13	12	12	11	11
Wyo:	Laramie	15	15	15	15	15	15	15	15	15	14
Network average		18.7	13.3	18.0	17.5	17.0	16.5	16.0	15.5	15.0	14.7

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (9) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–

90 to calcium in milk in a particular locality by 1.5."[3] Thus, a rough index of the total dietary intake of strontium-90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 g of calcium per liter in PMN samples and 1.0 g daily intake of calcium.

In the case of iodine-131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk.

Table 9. Moving annual average iodine-131 concentrations in milk for 12-month periods starting October 1964 and ending June 1966

Sampling location		Average iodine-131 concentrations, pCi/liter									
		Oct 1964–Sept 1965	Nov 1964–Oct 1965	Dec 1964–Nov 1965	Jan 1965–Dec 1965	Feb 1965–Jan 1966	Mar 1965–Feb 1966	Apr 1965–Mar 1966	May 1965–Apr 1966	June 1965–May 1966	July 1965–June 1966
Ala:	Montgomery	0	0	0	0	0	0	0	0	2	2
Alaska:	Palmer	1	1	1	1	1	1	1	1	2	2
Ariz:	Phoenix	0	0	0	0	0	0	0	0	0	0
Ark:	Little Rock	2	2	2	2	2	2	2	2	8	9
Calif:	Sacramento	1	1	1	1	1	1	1	1	0	0
	San Francisco	0	0	0	0	0	0	0	0	0	0
C.Z:	Cristobal	0	0	0	0	0	0	0	0	0	0
Colo:	Denver	2	2	2	2	2	2	2	2	2	1
Conn:	Hartford	0	0	0	0	0	0	0	0	0	0
Del:	Wilmington	2	2	1	1	1	1	1	1	2	1
D.C:	Washington	2	2	2	2	2	2	2	2	2	0
Fla:	Tampa	0	0	0	0	0	0	0	0	1	2
Ga:	Atlanta	1	1	1	1	1	1	1	1	2	2
Hawaii:	Honolulu	0	0	0	0	0	0	0	0	0	0
Idaho:	Idaho Falls	2	2	2	2	2	2	2	2	2	1
Ill:	Chicago	2	2	2	2	2	2	2	2	2	0
Ind:	Indianapolis	4	4	3	3	3	3	3	3	7	6
Iowa:	Des Moines	6	6	6	6	6	6	6	6	5	3
Kans:	Wichita	2	2	2	2	2	2	2	2	4	5
Ky:	Louisville	2	2	2	2	2	2	2	2	4	2
La:	New Orleans	2	2	2	2	2	2	2	2	2	2
Maine:	Portland	2	2	1	1	1	1	1	1	1	0
Md:	Baltimore	2	2	2	2	2	2	2	2	2	0
Mass:	Boston	0	0	0	0	0	0	0	0	0	0
Mich:	Detroit	3	2	2	2	2	2	2	2	2	1
	Grand Rapids	2	2	2	2	2	2	2	2	2	0
Minn:	Minneapolis	6	6	6	6	6	6	6	5	5	2
Miss:	Jackson	1	1	1	1	1	1	1	1	2	2
Mo:	Kansas City	8	8	8	8	8	8	8	8	9	7
	St. Louis	5	5	5	5	5	5	5	5	9	9
Mont:	Helena	3	2	2	2	2	2	2	2	0	0
Nebr:	Omaha	4	4	4	4	4	4	4	4	4	2
Nev:	Las Vegas	2	2	2	2	2	2	2	2	2	2
N.H:	Manchester	1	1	0	0	0	0	0	0	0	0
N.J:	Trenton	1	1	0	0	0	0	0	0	0	0
N. Mex:	Albuquerque	2	1	1	1	1	1	1	1	1	2
N.Y:	Buffalo	0	0	0	0	0	0	0	0	0	0
	New York	2	2	1	1	1	1	1	1	1	0
	Syracuse	1	1	1	1	1	1	1	1	1	0
N.C:	Charlotte	1	1	1	1	1	1	1	1	3	4
N. Dak:	Minot	2	2	2	2	2	2	2	2	2	0
Ohio:	Cincinnati	2	2	2	2	2	2	2	2	2	1
	Cleveland	2	2	2	2	2	2	2	2	2	0
Okla:	Oklahoma City	2	2	2	2	2	2	2	2	6	6
Ore:	Portland	1	1	1	1	1	1	1	1	1	1
Pa:	Philadelphia	0	0	0	0	0	0	0	0	0	0
	Pittsburgh	2	2	2	2	2	2	2	2	2	0
P.R:	San Juan	1	1	1	1	1	1	1	1	2	2
R.I:	Providence	0	0	0	0	0	0	0	0	3	0
S.C:	Charleston	1	1	1	1	1	1	1	1	3	4
S. Dak:	Rapid City	4	4	4	4	4	4	4	4	4	3
Tenn:	Chattanooga	1	1	1	2	2	2	2	2	3	3
	Memphis	2	2	2	2	2	2	2	2	4	4
Tex:	Austin	2	2	2	2	2	2	2	2	3	3
	Dallas	1	1	1	1	1	1	1	1	3	4
Utah:	Salt Lake City	2	2	2	2	2	2	2	2	2	1
Vt:	Burlington	2	1	0	0	0	0	0	0	0	0
Va:	Norfolk	3	3	3	3	3	3	3	3	2	1
Wash:	Seattle	1	1	1	1	1	1	1	1	1	1
	Spokane	0	0	0	0	0	0	0	0	0	1
W. Va:	Charleston	2	2	2	2	2	2	2	2	2	1
Wis:	Milwaukee	3	3	2	2	2	2	2	2	2	0
Wyo:	Laramie	2	2	2	2	2	2	2	2	2	0
Network average		2	2	2	2	2	2	2	2	2	2

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[3] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflects temporal and local distribution patterns (*10*).

With most other foods, normal processing and distribution allow time for the radioactive decay of this short-lived nuclide to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

Table 10. Moving annual average cesium-137 concentrations in milk for 12-month periods starting October 1964 and ending June 1966 [a]

Sampling location		Average cesium-137 concentrations, pCi/liter									
		Oct 1964–Sept 1965	Nov 1964–Oct 1965	Dec 1964–Nov 1965	Jan 1965–Dec 1965	Feb 1965–Jan 1966	Mar 1965–Feb 1966	Apr 1965–Mar 1966	May 1965–Apr 1966	June 1965–May 1966	July 1965–June 1966
Ala:	Montgomery	49	46	44	42	39	37	34	31	29	27
Alaska:	Palmer	64	61	58	57	55	54	52	49	47	46
Ariz:	Phoenix	22	21	21	19	19	17	16	16	15	14
Ark:	Little Rock	63	59	56	54	52	50	47	44	42	40
Calif:	Sacramento	29	28	28	27	25	23	22	21	19	18
	San Francisco	29	29	27	27	25	24	22	20	19	19
C.Z.:	Cristobal	39	37	35	34	33	32	30	29	28	27
Colo:	Denver	62	57	54	52	49	45	40	36	32	29
Conn:	Hartford	76	72	68	64	60	56	51	48	44	42
Del:	Wilmington	64	61	58	55	51	48	45	42	40	37
D.C:	Washington	48	45	44	43	40	38	35	33	31	29
Fla:	Tampa	181	174	168	162	156	153	148	144	138	135
Ga:	Atlanta	79	75	71	68	64	60	56	51	47	46
Hawaii:	Honolulu	59	56	54	51	48	45	43	40	37	36
Idaho:	Idaho Falls	84	82	79	75	68	63	58	53	48	44
Ill:	Chicago	68	65	62	59	54	50	46	42	38	36
Ind:	Indianapolis	54	51	48	44	41	37	34	31	29	28
Iowa:	Des Moines	50	48	45	42	40	36	35	32	29	28
Kans:	Wichita	42	40	40	37	34	31	28	26	24	22
Ky:	Louisville	44	41	39	37	34	31	28	25	24	23
La:	New Orleans	75	71	68	66	63	61	56	52	49	47
Maine:	Portland	124	117	110	104	97	92	87	82	76	74
Md:	Baltimore	54	52	50	48	45	42	39	35	32	31
Mass:	Boston	117	112	107	101	93	88	81	74	68	66
Mich:	Detroit	67	63	60	56	52	48	43	40	35	33
	Grand Rapids	76	72	68	65	61	58	53	50	47	44
Minn:	Minneapolis	77	74	72	67	63	60	55	51	46	43
Miss:	Jackson	52	49	46	44	41	39	35	33	32	31
Mo:	Kansas City	42	41	39	37	34	31	28	26	24	23
	St. Louis	41	39	37	34	32	30	29	27	25	25
Mont:	Helena	83	79	76	73	70	66	63	59	56	53
Nebr:	Omaha	50	48	47	45	43	40	38	36	35	33
Nev:	Las Vagas	37	36	34	31	29	28	26	24	22	22
N.H:	Manchester	140	133	125	118	109	103	97	92	83	80
N.J:	Trenton	65	62	58	54	51	47	44	40	37	35
N. Mex:	Albuquerque	36	34	31	29	27	24	22	19	17	17
N.Y:	Buffalo	84	80	76	72	66	60	55	49	43	41
	New York	85	80	76	71	65	61	56	51	46	45
	Syracuse	75	71	67	62	56	52	48	43	40	38
N.C:	Charlotte	59	56	52	50	46	44	41	38	35	33
N. Dak:	Minot	103	97	92	86	78	72	66	60	53	46
Ohio:	Cincinnati	51	48	45	42	38	34	31	28	27	25
	Cleveland	69	65	62	57	52	48	43	38	35	33
Okla:	Oklahoma City	42	40	38	36	33	31	29	26	24	22
Ore:	Portland	82	78	74	69	66	59	54	49	45	41
Pa:	Philadelphia	60	57	54	51	48	45	41	38	35	33
	Pittsburgh	84	80	76	72	66	62	57	52	48	46
P.R:	San Juan	48	46	44	42	39	37	35	33	31	29
R.I:	Providence	90	86	81	77	72	68	64	59	53	51
S.C:	Charleston	87	85	82	78	74	72	68	63	57	55
S. Dak:	Rapid City	101	96	91	84	76	68	61	55	50	46
Tenn:	Chattanooga	59	55	52	50	46	43	39	37	34	32
	Memphis	39	37	35	33	31	29	26	24	22	20
Tex:	Austin	26	25	24	23	22	20	18	17	16	15
	Dallas	37	36	35	33	31	29	27	24	23	22
Utah:	Salt Lake City	99	94	91	85	77	70	64	57	48	43
Vt:	Burlington	98	94	89	84	78	73	68	63	57	55
Va:	Norfolk	55	52	49	46	43	41	38	36	32	30
Wash:	Seattle	90	85	81	77	73	69	65	62	57	53
	Spokane	85	80	76	71	64	60	56	52	47	44
W. Va:	Charleston	39	37	36	34	32	30	28	25	23	23
Wis:	Milwaukee	78	74	70	66	61	57	52	48	43	41
Wyo:	Laramie	63	62	59	57	54	51	48	44	42	39
Network average		67	64	61	58	54	50	47	43	40	38

[a] Annual averages for barium-140 at each station were <3 pCi/liter.

The relative contribution of milk to the total dietary intake of cesium-137 is not well defined and depends principally on the amount of freshly deposited cesium-137 on products used for human and animal consumption, and on the progress of cesium-137 through the food chain.

The data in tables 7 to 10 are calculated as follows: results from all samples collected each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of 12 consecutive months are averaged to obtain the annual average.[4] To obtain the annual average daily intake (pCi/day) of radionuclides from milk, the annual average concentration values (pCi/liter) in tables 7 to 10 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average obtained by updating the previous 12-month average by 1 month shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

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(*4*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Radiol Health Data 6:687 (December 1965).

(*5*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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(*9*) FEDERAL RADIATION COUNCIL. Estimates and evaluation of fallout in the United States from nuclear weapons testing conducted through 1962, Report No. 4. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1963).

(*10*) FEDERAL RADIATION COUNCIL. Revised fallout estimates for 1964-1965 and verification of the 1963 predictions, Report No. 6. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (October 1964).

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[4] Beginning with the October 1963 data, iodine-131 values of <10 pCi/liter are considered to be zero for averaging purposes; previously, 5 pCi/liter was used for calculating the averages.

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs supported by functional radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	Period reported	Last presented
California	January–March 1966	September 1966
Connecticut	January–March 1966	August 1966
Indiana	January–March 1966	August 1966
Michigan	October–December and annual summary 1965	May 1966
Minnesota	January–March 1966	August 1966
New York	July–December and annual summary 1965	May 1966
Oregon	January–March 1966	September 1966
Pennsylvania	January–March 1966	August 1966
Washington	January–March 1966	September 1966

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1. Colorado Milk Network
January 1965—June 1966

Occupational and Radiological Health Division
Colorado State Department of Public Health

The Radiological Health Division of the Colorado State Department of Public Health initiated radiological analysis of milk in January 1962. Initially, the Denver City and County Health Department collected a weekly composite milk sample from the major producers in the Denver area for the State, as it had for the Public Health Service since March 1960.

In August 1962, the State expanded its program to include the routine sampling of raw milk from the four major milk producing areas supplying the State: northeastern, southeastern, and western Colorado, and eastern Utah. The five Colorado milk sampling areas are shown in figure 1.

Recent analyses have been made on samples coming into the State Health Department primarily for other purposes. Frequent sampling has been resumed only in response to some nuclear test announcements. At this present time, samples from each area may be either local or imported milk and may be either raw or pasteurized.

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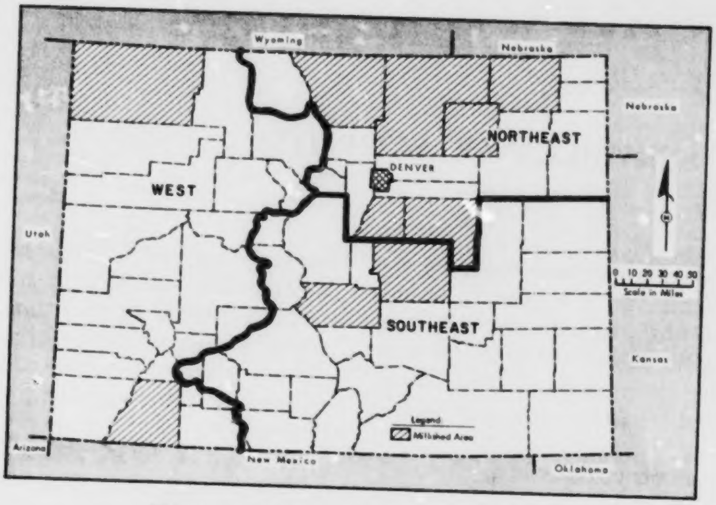
Wyoming
Nebraska
Nebraska
NORTHEAST
DENVER
WEST
Utah
SOUTHEAST
0 10 20 30 40 50
Scale in Miles
Kansas
Legend
Milkshed Area
Arizona
New Mexico
Oklahoma

Figure 1. Colorado milk sampling areas

Table 1. Potassium and radionuclides in Colorado milk, May to December 1965 and May–June 1966

Date	Denver			Northeastern			Southeastern			Western			Eastern Utah		
	Potassium (g/liter)	Iodine-131 (pCi/liter)	Cesium-137 (pCi/liter)	Potassium (g/liter)	Iodine-131 (pCi/liter)	Cesium-137 (pCi/liter)	Potassium (g/liter)	Iodine-131 (pCi/liter)	Cesium-137 (pCi/liter)	Potassium (g/liter)	Iodine-131 (pCi/liter)	Cesium-137 (pCi/liter)	Potassium (g/liter)	Iodine-131 (gCi/liter)	Cesium-137 (gCi/liter)
1965															
May	1.9 1.8 1.9 1.6	<10 <10 <10 <10	45 43 70 50	1.6 1.7 1.6	<10 <10 <10	15 25 44	1.7	<10	27						
June	1.4 1.3 1.5 1.7	<10 26 <20 <10	42 49 55 56	1.2 1.2 1.4 1.0	<10 <10 <10 <10	45 42 43 36									
July	1.5 1.7	<10 <10	37 11	1.3 1.6	<10 <10	30 12									
August	1.7 1.6 1.5 1.7	<10 <10 <10 <10	14 13 60 21	1.3 1.7	<10 <10	30 41	1.7	<10	54	------	------	------	1.6	<10	42
September	1.4 1.7 1.6 1.7	<10 <10 20 <10	27 20 39 11	1.5 ------	<10 ------	31 ------	1.2 1.6	<10 <10	44 17	1.4	<20	<20	1.8	<20	20
October	1.7 1.7 2.0 1.7	<10 <10 <20 <10	5 17 12 12	------	------	------	------	------	------	------	------	------	1.5	<10	34
November	------	------	------	------	------	------	1.5	<10	20						
December	1.7	<10	21												
1966															
May	1.3 1.3 1.5 1.7 1.7 1.4 1.6 1.5 1.5 1.5 1.6 1.4	<10 <10 <10 <10 <10 <10 <10 <10 <10 <10 <10 <10	17 12 11 12 18 25 16 16 15 16 <10 19	1.4 1.5 1.5 ------ ------ ------ ------ ------ ------ ------ ------	<10 <10 <10 ------ ------ ------ ------ ------ ------ ------ ------	19 15 10 ------ ------ ------ ------ ------ ------ ------ ------	1.5 1.4 1.4 1.4 1.6 1.9 1.5 1.4 1.2 1.2 1.5	<10 <10 <10 <10 <10 <10 <10 <10 <10 <10 <10	19 14 <10 <10 <10 34 23 18 11 14 12	1.2 1.8	<10 <10	<10 26	1.6 1.6	<10 <10	<10 41
June	------ ------	------ ------	------ ------	------ ------	------ ------	------ ------	1.8 ------	<10 ------	19 ------	1.6 1.8	<20 <10	13 11			

Analyses are conducted for potassium, iodine–131, cesium–137, and barium–140, using gamma spectroscopy. The gamma measurement system used for milk analysis has been modified since results were last reported in 1965 (*1*). Currently a 4- by 5-inch NaI crystal shielded by a modified safe is used.

Minimum detectable amounts at the 95-percent confidence level are as follows: iodine–131 (10 pCi/liter); barium-lanthanum–140 (15 pCi/liter); cesium–137 (10 pCi/liter); and potassium (0.2 g/liter).

Table 1 gives stable potassium, iodine–131, and cesium–137 concentrations in milk determined on samples collected from May 1965 through June 1966. During this period, barium-lanthanum–140 was not detected. Results for January through April 1965 and January through April 1966 are not available.

Previous coverage in *Radiological Health Data:*

Period	Issue
July–September 1964	February 1965
October–December 1964 and summary for 1962–1964	April 1965

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2. Florida Milk Network April–June 1966

Division of Radiological and Occupational Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium–89, strontium–90, and cesium–137, in addition to iodine–131. Raw milk samples are received from the six areas shown in figure 2. Monthly samples are taken from randomly selected farms in the areas represented. A regional State Board of Health laboratory is located in each of the six areas referred to in this report. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. In the interest of maintaining an active standby capability, samples are now collected and analyzed for iodine–131 on a monthly basis using the resin cartridge technique. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms in the west Florida region, where locally grown feeds are used, to larger farms in the southern areas, where different types of grass and predominately purchased feeds are used.

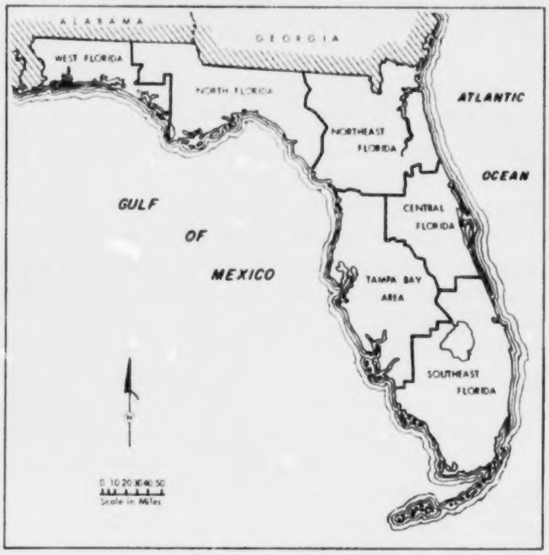

Figure 2. Florida milk sampling areas

Strontium–89 and strontium–90 are determined by the ion exchange method developed by Porter *et al.*(*2*). Iodine–131 and cesium–137 are determined by gamma-scintillation spectrometry (*3*).

Radionuclide concentration levels for April through June 1966 are presented in tables 2 and 3. Strontium–89 analyses have been discontinued due to extremely low levels during 1965. During this period, iodine–131 concentrations were below the minimum detectable level of 30 pCi/liter.

Table 2. Strontium-90 in Florida raw milk, April–June 1966

Month	Concentration, pCi/liter						
	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Florida	Southeast Florida	Average
April	28.4	19.4	14.5	15.0	8.2	7.5	15.5
May	29.0	21.0	8.3	NS	9.3	8.5	15.2
June	36.8	20.6	8.3	14.9	11.5	10.2	17.0
Average	31.4	20.5	10.4	14.9	9.7	8.9	15.9

NS, no sample

Table 3. Cesium-137 in Florida raw milk, April–June 1966

Month	Concentration, pCi/liter						
	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Florida	Southeast Florida	Average
April	21	55	144	100	130	84	90
May	27	55	120	100	144	80	89
June	40	22	129	154	107	115	94
Average	29	44	131	124	128	93	91

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Annual summary 1964	November 1965
January–June 1965	January 1966
July–December 1965	April 1966
January–March 1966	July 1966

3. Oklahoma Milk Network
April–June 1966

Oklahoma State Department of Health[1]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine–131 in the milk produced in the State of Oklahoma. On March 7, 1966, analysis for cesium–137 was added to the program.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 3. Of the 10 milksheds in the State of Oklahoma, 5 were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of their size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the concentration of radioactivity might be abnormally high.

The sampling stations are located in the laboratory of a major milk-processing plant in each milkshed. While the milkshed for a particular processing plant may not coincide exactly with that shown in figure 3, the coincidence is satisfactory for surveillance purposes.

At the present time, samples are collected on Monday morning, and the analyses are completed by Wednesday afternoon. However, if iodine–131 or cesium–137 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample each truck arriving at the processing plant. Under these conditions, only about 4 hours would be needed to complete the analysis. This greatly reduced lag time for analysis would permit rapid decisions on the fate of each truckload of raw milk.

The analytical procedure used is a modification of those published by Boni (*4*) and Porter (*5*) and consists of passing 1 quart of milk through a two-section cartridge containing Dowex 1X8, 50–100 mesh in one section and potassium cobalt ferrocyanide (KCFC) in the other. Iodine–131 is adsorbed on the Dowex 1X8 and cesium–137 on the KCFC.

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[1] Acknowledgment is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert Craig, assistant engineer.

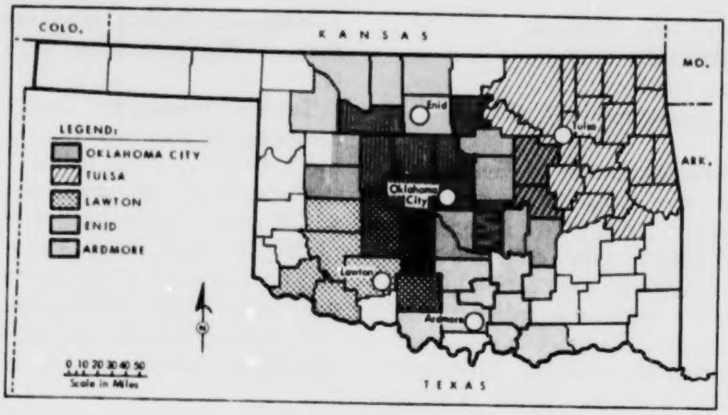

Figure 3. Oklahoma milkshed sampling areas

In practice, the cartridges are prepared in the laboratory and mailed to the sampling stations where pasteurized milk is passed through them. The cartridges are returned to the laboratory where the sections are separated and the ion exchange media counted for 100 minutes in a 2-by 2-inch sodium iodide well crystal attached to a multichannel analyzer.

Table 4. Concentration of iodine-131 in Oklahoma milk April–June 1966

Date 1966	Sampling location, concentrations in pCi/liter					
	Oklahoma City	Enid	Tulsa	Lawton	Ardmore	Oklahoma City *
April 1	ND	ND	ND	ND	ND	NS
18	5	ND	ND	ND	ND	NS
May 2	ND	ND	ND	ND	ND	NS
16	ND	ND	ND	ND	ND	NS
20	NS	NS	NS	NS	NS	8
23	39	49	208	7	21	NS
24	NS	NS	NS	NS	NS	103
31	83	70	49	103	26	81
June 2	NS	NS	NS	NS	NS	118
6	NS	36	42	21	23	61
10	NS	NS	NS	NS	NS	18
13	NS	17	20	13	11	23
17	NS	NS	NS	NS	NS	15
20	14	12	13	6	8	11
27	ND	4	6	ND	ND	ND

* Sample split with PHS Pasteurized Milk Network sample from Oklahoma City station.
ND, non-detectable, concentrations less than 3.3 pCi/liter.
NS, no sample received.

The limits of detection, defined as the 3σ error of background, are 3.3 pCi/liter for iodine–131 and 9.7 pCi/liter for cesium–137.

Table 4 gives the concentration of iodine–131 in Oklahoma milk for the period April 4 through June 27, 1966. Table 5 gives the concentration of cesium–137 for the period March 7 through June 27, 1966.

Table 5. Concentration of cesium-137 in Oklahoma milk March–June 1966

Date 1966	Sampling location, concentrations in pCi/liter					
	Oklahoma City	Enid	Tulsa	Lawton	Ardmore	Oklahoma City *
March 7	NS	NS	34	20	23	NS
14	21	NS	NS	NS	NS	NS
April 1	21	13	62	15	22	NS
18	24	15	25	33	19	NS
May 2	24	19	22	20	23	NS
16	18	33	41	11	NS	NS
20	NS	NS	NS	NS	NS	35
23	20	22	45	29	21	NS
24	NS	NS	NS	NS	NS	34
31	29	19	35	19	18	27
June 2	NS	NS	NS	NS	NS	26
6	NS	29	27	18	ND	22
10	NS	NS	NS	NS	NS	26
13	NS	25	35	23	22	25
17	NS	NS	NS	NS	NS	30
20	20	20	29	13	38	21
27	21	20	29	20	15	15

* Sample split with PHS Pasteurized Milk Network sample from Oklahoma City station.
NS, no sample received.
ND, non-detectable, concentrations less than 9.7 pCi/liter.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
March–July 1965	October 1965
August–December 1965	April 1966
January–March 1966	July 1966

4. Texas Milk Network
April–June 1966

Texas State Department of Health[2]

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of six active sampling points. In addition, six standby stations have been supplied sample containers and shipping instructions and can be activated immediately, if needed. The active and standby station locations, shown in figure 4, were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium-89 and strontium-90 by a chemical separation technique employing ion exchange columns (*6*).

Potassium-40, iodine-131, cesium-137, and barium-140, concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*7*).

Table 6 presents the April through June 1966 radionuclide concentrations in Texas milk for the active sampling points. Table 7 presents the results of the standby sampling stations which were activated following the Chinese test of May 9, 1966. During this time, strontium-89 and barium-140 concentrations were below detectable levels. Strontium-90 and cesium-137 concentrations are shown graphically in figure 5 to indicate general trends.

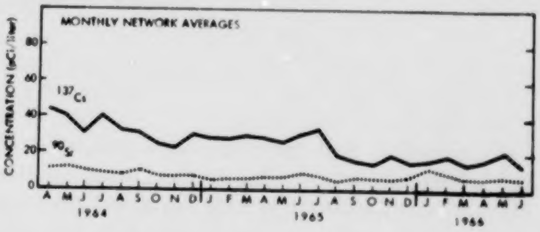

Figure 5. Radionuclide concentrations in Texas milk 1964–June 1966

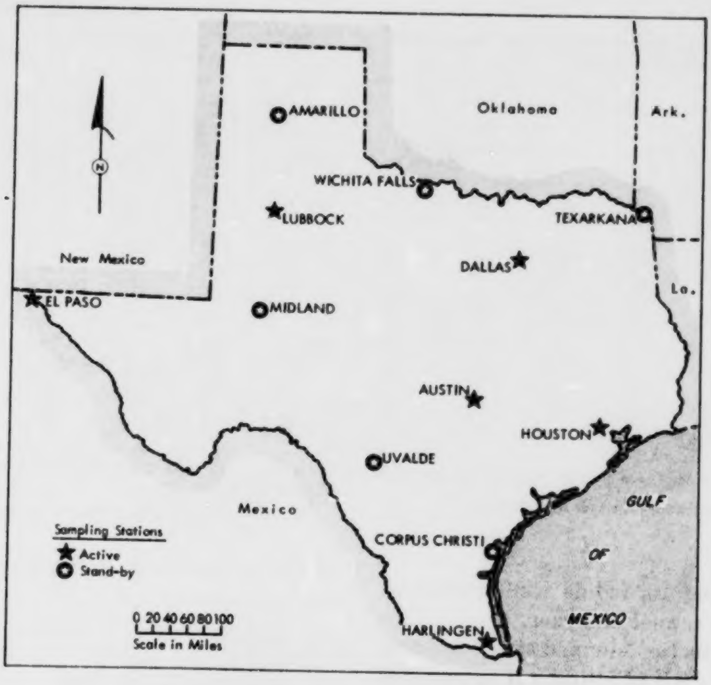
N
AMARILLO
Oklahoma
Ark.
WICHITA FALLS
LUBBOCK
TEXARKANA
New Mexico
DALLAS
La.
EL PASO
MIDLAND
AUSTIN
HOUSTON
UVALDE
GULF
Mexico
Sampling Stations
Active
Stand-by
CORPUS CHRISTI
OF
0 20 40 60 80 100
Scale in Miles
MEXICO
HARLINGEN

Figure 4. Texas milk sampling stations

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[2] Acknowledgment is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

Table 6. Radionuclide concentrations in Texas milk, April–June 1966

Active sampling stations	Potassium-40, pCi/liter			Strontium-90, pCi/liter		
	April	May	June	April	May	June
Austin	NS	1,280	1,190	NS	5	5
Dallas	NS	1,240	1,250	NS	7	5
El Paso	1,290	1,340	1,280	3	4	5
Harlingen	1,320	1,250	1,300	3	5	4
Houston	1,250	1,280	1,260	12	12	11
Lubbock	1,100	1,280	1,240	5	6	7
Average	1,240	1,280	1,250	5.8	6.5	6.1
	Iodine-131, pCi/liter			Cesium-137 pCi/liter		
Austin	NS	ND	10	NS	20	13
Dallas	NS	40	10	NS	25	15
El Paso	ND	5	7	10	15	13
Harlingen	ND	2	5	5	12	13
Houston	ND	10	5	40	35	25
Lubbock	ND	43	8	15	17	16
Average	ND	16.7	7.5	17.5	20.7	16.0

NS, no sample collected.
ND, below detectable levels.

Table 7. Radionuclide concentrations in Texas milk, May–June 1966

Standby sampling stations	Number of samples		Potassium-40 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)		Barium-140 (pCi/liter)		Cesium-137 (pCi/liter)	
	May	June	May	June	May	June	May	June	May	June	May	June
Amarillo	2	4	1,270	1,200	7	5	25	20	ND	ND	20	14
Corpus Christi	2	6	1,240	1,230	4	4	15	13	ND	ND	20	15
Galveston	2	5	1,220	1,200	9	12	ND	10	ND	ND	38	35
Lubbock	3	4	1,280	1,240	6	7	45	10	ND	ND	17	16
Midland	1	3	1,260	1,300	3	3	10	13	ND	ND	10	20
Texarkana	2	2	1,290	1,250	15	18	110	ND	15	ND	40	35
Wichita Falls	1	5	1,300	1,210	12	9	140	15	15	ND	25	15

ND, below detectable level.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
1964 Summary	June 1965
January–March 1965	October 1965
April–December 1965	April 1966
January–March 1966	July 1966

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FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are listed below:

Program	Period reported	Last presented
Tri-City Diet, HASL	November 1965–January 1966	September 1966
Teenage Diet, FDA	February–November 1965	August 1966
California Diet	September–December 1965	September 1966
Connecticut Standard Diet	January–June 1965	February 1966

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1. Radionuclides in Institutional Total Diet Samples

January–March 1966

Division of Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Total Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program was designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicted that the number of institutions sampled could be selectively reduced. As of July 1965, 21 institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily intake of teenage girls and that of children from 9 to 12 years of age were comparable, while teenage boys consumed 20 per-

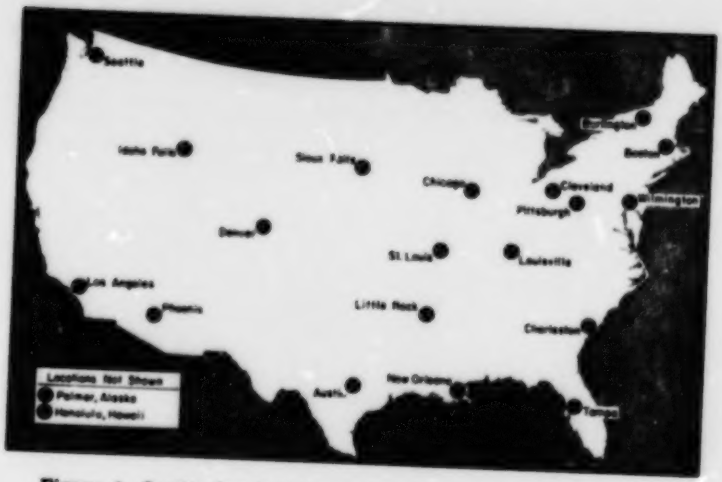

Figure 1. Institutional diet sampling locations as of July 1965

cent more food per day (*1,2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. The monthly sample supplied by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada; the Southeastern Radiological Health Laboratory, Montgomery, Alabama; or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts. A detailed description of sampling and analytical procedures was presented elsewhere (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from January through March 1966, for children 9 to 12 years of age. The stable elements calcium and potassium are reported in g/kg of diet, and the radionuclide concentrations of strontium–89, strontium–90, cesium–137, and radium–226 are expresed as pCi/kg of diet.

Dietary intakes, presented in table 2, were obtained by multiplying the food consumption rate in kg/day by the concentration values given in table 1. The reported radionuclide concentrations of these samples are collected for radioactive decay to the midpoint of the sample collection period, where applicable.

Certain of the radionuclide concentration results have been reported as being "less than" a specified value. For the purpose of obtaining dietary intakes, "less than" 5 pCi/kg of strontium–89 was interpreted as 2.5 pCi/kg, and "less than" 10 pCi/kg values for iodine–131 and barium–140 were interpreted as zero.

The average food consumption rate during this period was 1.90 kg/day and was the same as the network average of 1.90 kg/day observed from 1961 through 1964 (*4*).

While strontium–89 dietary intake remained below detectable levels, the strontium–90 dietary intake during this period remained fairly constant at approximately 22 pCi/day. These results fall within Range II as defined by the Federal Radiation Council (*5*), indicating that quantitative surveillance and routine control are recommended.

Table 1. Stable element and radionuclide concentrations in institutional total diets of children (9–12 years of age) January–March 1966[a]

Location of institution		Month 1966	Stable elements, g/kg of diet		Radionuclide concentrations, pCi/kg of diet			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska:	Palmer	Jan	0.7	1.3	<5	13	45	0.5
		Feb	1.0	0.9	<5	27	55	0.6
		Mar	0.5	1.2	<5	15	40	0.4
Ariz:	Phoenix	Jan	0.7	1.1	<5	10	25	0.4
		Feb	0.7	1.0	<5	14	35	0.2
		Mar[b]	0.6	1.1	<5	11	25	0.4
Ark:	Little Rock	Jan	0.7	1.4	<5	12	20	0.7
		Feb	0.7	1.5	<5	20	30	1.1
		Mar	0.7	1.6	<5	14	20	1.2
Calif:	Los Angeles	Jan	0.7	1.2	<5	7	20	0.3
		Feb	0.9	1.7	<5	8	20	0.4
		Mar	1.0	1.2	<5	16	20	1.0
Colo:	Denver	Jan	0.8	1.5	<5	15	30	0.2
		Feb	0.7	1.2	<5	10	20	0.4
		Mar	0.7	0.9	<5	12	10	0.5
Del:	Wilmington	Jan	0.7	1.6	<5	11	35	0.9
		Feb	0.8	1.6	<5	10	40	1.1
		Mar	0.7	1.7	<5	11	40	0.7
Fla:	Tampa	Jan	0.7	1.4	<5	9	70	1.3
		Feb	0.9	1.6	<5	14	45	1.4
		Mar	0.7	1.5	<5	10	60	1.5
Hawaii:	Honolulu	Jan	0.5	1.3	<5	5	35	0.2
		Feb	0.5	1.2	<5	5	25	0.4
		Mar	0.5	1.4	<5	5	25	0.5
Idaho:	Idaho Falls	Jan	0.8	1.3	<5	9	45	0.7
		Feb	0.8	1.5	<5	16	35	0.8
		Mar	0.7	1.4	<5	11	40	0.5
Ill:	Chicago	Jan	0.8	1.5	<5	7	45	0.6
		Feb	0.7	1.4	<5	9	45	0.5
		Mar	0.8	1.5	<5	9	40	0.4
Ky:	Louisville	Jan	0.8	1.9	<5	12	25	1.2
		Feb	1.0	1.5	<5	16	25	2.1
		Mar	0.9	1.7	<5	14	30	1.3
La:	New Orleans	Jan	0.7	1.8	<5	19	35	0.4
		Feb	0.8	1.6	<5	16	40	1.4
		Mar	0.8	1.4	<5	17	30	1.0
Mass:	Boston	Jan	0.5	1.4	<5	8	45	0.7
		Feb	0.5	1.4	<5	7	25	0.5
		Mar	0.6	1.4	<5	7	35	0.6
Mo:	St Louis	Jan	0.8	1.7	<5	10	40	0.9
		Feb	0.8	1.7	<5	11	30	0.5
		Mar	0.6	1.5	<5	11	35	0.8
Ohio:	Cleveland	Jan	0.6	1.8	<5	9	35	0.8
		Feb	0.6	1.7	<5	9	55	0.7
		Mar	0.6	1.7	<5	11	40	0.3
Pa:	Pittsburgh	Jan	0.7	1.4	<5	12	45	0.7
		Feb	0.8	1.6	<5	10	30	1.2
		Mar	0.6	1.2	<5	10	30	0.5
S.C:	Charleston	Jan	0.8	1.6	<5	20	45	1.4
		Feb	0.8	1.5	<5	13	40	1.5
		Mar	0.7	1.5	<5	15	35	1.4
S. Dak:	Sioux Falls	Jan	0.8	1.7	<5	14	70	0.7
		Feb	0.8	1.4	<5	13	40	0.8
		Mar	0.8	1.7	<5	14	60	0.6
Tex:	Austin	Jan	0.6	1.3	<5	8	20	1.8
		Feb	0.6	1.4	<5	7	15	1.5
		Mar	0.6	1.4	<5	7	25	1.8
Vt:	Burlington	Jan	0.7	1.7	<5	12	65	0.8
		Feb	0.7	1.5	<5	13	40	0.7
		Mar	0.7	1.5	<5	11	45	0.8
Wash:	Seattle	Jan	0.7	1.5	<5	10	50	0.3
		Feb	0.8	1.6	<5	17	70	0.4
		Mar	0.7	1.4	<5	12	40	0.4
Institutional average		Jan	0.7	1.5	<5	11	40	0.7
		Feb	0.8	1.5	<5	13	35	10.9
		Mar	0.7	1.4	<5	12	35	0.8

[a] During the first quarter of 1966, both iodine-131 and barium-140 concentrations were below detectable levels.
[b] The food sample for this month did not contain the milk portion of the diet.
NA, no analysis.

Cesium-137 intakes averaged 67 pCi/day during this period. Both barium-140 and iodine-131 concentrations were below detectable levels.

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Table 2. Intake of stable elements and radionuclides in institutional total diet for children (9–12 years of age) January–March 1966

Location of institution		Month 1966	Total weight (kg/day)	Stable elements intakes, g/day		Radionuclide intakes, pCi/day			
				Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska:	Palmer	Jan	1.68	1.2	2.2	5	22	75	0.8
		Feb	1.93	1.9	1.7	5	52	105	1.2
		Mar	1.89	0.9	2.3	5	28	75	0.8
Ariz:	Phoenix	Jan	2.16	1.5	2.4	5	22	55	0.9
		Feb	1.98	1.4	2.0	5	28	70	0.4
		Mar	[a] 1.67	1.0	1.8	5	18	40	0.7
Ark:	Little Rock	Jan	1.87	1.3	2.6	5	22	35	1.3
		Feb	1.87	1.3	2.8	5	37	55	2.1
		Mar	1.61	1.1	2.6	5	23	30	1.9
Calif:	Los Angeles	Jan	2.06	1.4	2.5	5	14	40	0.6
		Feb	2.13	1.9	3.6	5	17	45	0.9
		Mar	1.91	1.9	2.3	5	31	40	1.9
Colo:	Denver	Jan	2.26	1.8	3.4	5	34	70	0.5
		Feb	2.19	1.5	2.6	5	22	45	0.9
		Mar	2.82	2.0	2.5	5	34	30	1.4
Del:	Wilmington	Jan	2.05	1.4	3.3	5	22	70	1.8
		Feb	1.80	1.4	2.9	5	18	70	2.0
		Mar	2.14	1.5	3.6	5	24	85	1.5
Fla:	Tampa	Jan	2.13	1.5	3.0	5	19	150	2.8
		Feb	2.04	1.8	3.3	5	29	90	2.9
		Mar	2.03	1.4	3.0	5	20	120	3.0
Hawaii:	Honolulu	Jan	1.98	1.0	2.6	5	10	70	0.4
		Feb	2.03	1.0	2.4	5	10	50	0.8
		Mar	2.13	1.1	3.0	5	11	55	1.1
Idaho:	Idaho Falls	Jan [b]	1.92	1.5	2.5	5	17	85	1.3
		Feb [b]	1.82	1.5	2.7	5	29	65	1.5
		Mar [b]	1.90	1.3	2.7	5	21	75	1.0
Ill:	Chicago	Jan [b]	1.72	1.4	2.6	5	12	75	1.0
		Feb	1.46	1.0	2.0	5	13	65	0.7
		Mar [b]	1.69	1.4	2.5	5	15	70	0.7
Ky:	Louisville	Jan	1.33	1.1	2.5	5	16	35	1.6
		Feb	1.38	1.4	2.1	5	22	35	2.9
		Mar	1.22	1.1	2.1	5	17	35	1.6
La:	New Orleans	Jan	1.73	1.2	3.1	5	33	60	0.7
		Feb [c]	2.08	1.7	3.3	5	33	85	2.9
		Mar [c]	2.14	1.7	3.0	5	36	65	2.1
Mass:	Boston	Jan	2.37	1.2	3.3	5	19	105	1.7
		Feb	2.39	1.2	3.3	5	17	60	1.2
		Mar	2.51	1.5	3.5	5	18	90	1.5
Mo:	St. Louis	Jan	2.59	2.1	4.4	5	26	105	2.3
		Feb	2.57	2.1	4.4	5	28	75	1.3
		Mar	2.57	1.5	3.9	5	28	90	2.1
Ohio:	Cleveland	Jan	1.57	0.9	2.8	5	14	55	1.3
		Feb	1.77	1.1	3.0	5	16	95	1.2
		Mar	1.67	1.0	2.8	5	18	65	0.5
Pa:	Pittsburgh	Jan [b]	2.24	1.6	3.1	5	27	100	1.6
		Feb [b]	2.36	1.9	3.8	5	24	70	2.8
		Mar [b]	2.33	1.4	2.8	5	23	70	1.2
S.C:	Charleston	Jan	1.43	1.1	2.3	5	29	65	2.0
		Feb	1.74	1.4	2.6	5	23	70	2.6
		Mar [d]	1.78	1.2	2.7	5	26	60	2.5
S. Dak:	Sioux Falls	Jan	1.75	1.4	3.0	5	24	120	1.2
		Feb	1.91	1.5	2.7	5	25	75	1.5
		Mar	1.82	1.5	3.1	5	25	110	1.1
Tex:	Austin	Jan	1.59	1.0	2.1	5	13	30	2.9
		Feb	1.72	1.0	2.4	5	12	25	2.6
		Mar	1.69	1.0	2.4	5	12	40	3.0
Vt:	Burlington	Jan	1.31	0.9	2.2	5	16	85	1.0
		Feb	1.36	1.0	2.0	5	18	55	1.0
		Mar	1.21	0.8	1.8	5	13	55	1.0
Wash:	Seattle	Jan [b]	1.73	1.2	2.6	5	17	85	0.5
		Feb [b]	1.53	1.2	2.4	5	26	105	0.6
		Mar [b]	1.30	0.9	1.8	5	16	50	0.5
Institutional average		Jan	1.87	1.3	2.8	5	21	70	1.4
		Feb	1.90	1.4	2.7	5	23	65	1.5
		Mar	1.93	1.3	2.7	5	21	65	1.5

[a] The food sample for this month did not contain the milk portion of the diet.

[b] Data for this month were not used in computing the average for all institutions since food samples were collected from two or more children over 12 years of age.

[c] Data for this month were not used in computing the average for all institutions since food samples were collected from two or more children under 9 years of age.

[d] Data for this month were not used in computing the average for all institutions since food samples were collected from children whose ages were not given.

(5) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–March 1964	October 1964
April–June 1964	January 1965
July–September 1964	April 1965
October–December and annual averages 1964	July 1965
January–March 1965	October 1965
April–June 1965	February 1966
July–September 1965	May 1966
October–December and annual averages 1965	July 1966

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross alpha and gross beta radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below:

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

Program	Period reported	Last presented
Radiostrontium in Tap Water, HASL	May and July–November 1965	June 1966
California Water Sampling Program	January–June 1965	March 1966
Colorado River Basin Sampling Network	1962–1964	November 1965
Coast Guard Water Sampling Program	1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Minnesota Surface Water Sampling Program	July–December 1965	July 1966
New York Surface Water Sampling Program	June–December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Publication 1956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, APRIL 1966

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure

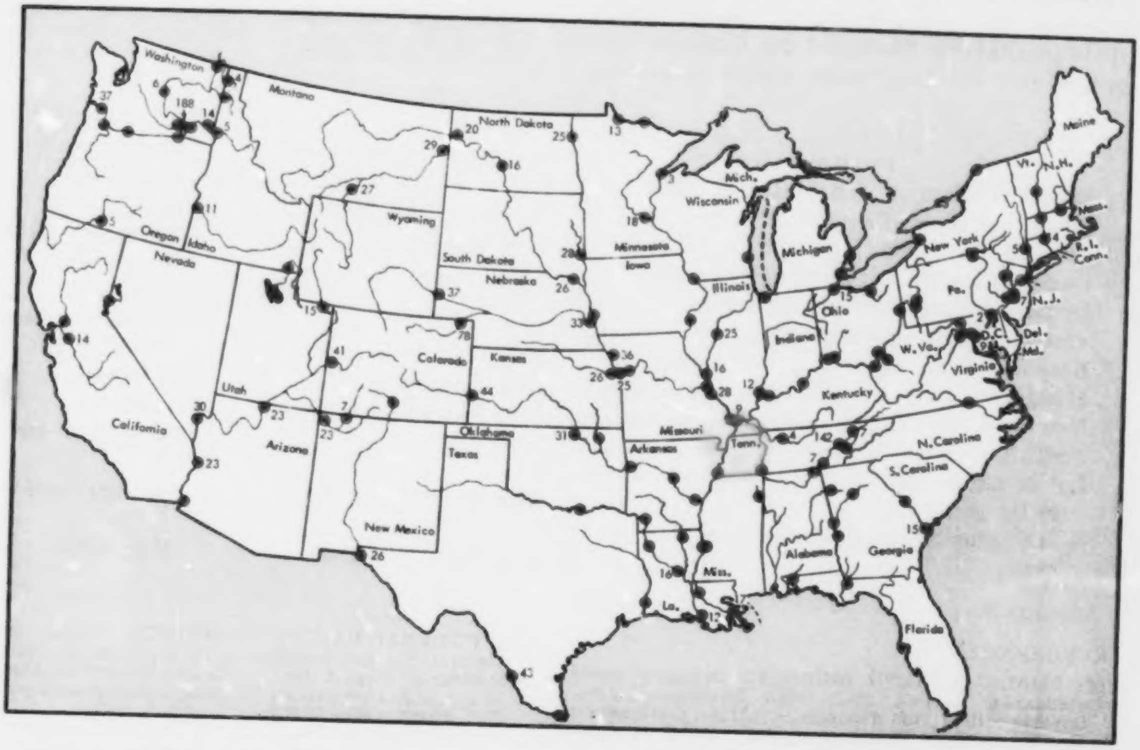
Washington
37
6
188
14
4
5
Montana
North Dakota
20
29
25
16
13
27
11
5
Oregon
Idaho
Wyoming
South Dakota
Nebraska
Nevada
28
26
37
15
14
33
78
41
Colorado
Kansas
26
36
25
44
Utah
30
7
23
23
California
Arizona
23
Oklahoma
31
Texas
New Mexico
26
43
Minnesota
Iowa
18
3
Wisconsin
Mich.
Michigan
Illinois
25
16
28
12
9
Indiana
Ohio
15
Missouri
Arkansas
Tenn.
4
142
7
7
Kentucky
W. Va.
Virginia
N. Carolina
S. Carolina
15
Georgia
Alabama
Miss.
16
La.
12
17
Florida
New York
Pa.
56
4
7
2
N. J.
D.C.
98
Del.
Md.
Maine
Vt.
N.H.
Mass.
R.I.
Conn.

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, April 1966

Table 1. Radioactivity in raw surface waters, April 1966

Stations	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	1	6	7	0	2	2
Arkansas River:						
Coolidge, Kans	3	41	44	<1	17	17
Ponca City, Okla	6	25	31	1	7	8
Atchafalaya River:						
Morgan City, La	3	9	12	1	1	2
Big Horn River:						
Hardin, Mont	5	22	27	2	8	10
Big Sioux River:						
Sioux Falls, S. Dak	6	22	28	1	1	2
Chena River:						
Fairbanks, Alaska	<1	2	2	0	<1	<1
Clearwater River:						
Lewiston, Idaho	2	3	5	0	0	0
Clinch River:						
Clinton, Tenn	3	4	7	0	0	0
Kingston, Tenn *	7	135	142	0	1	1
Colorado River:						
Loma, Colo	30	11	41	8	3	11
Page, Ariz	1	22	23	0	6	6
Boulder City, Nev	1	29	30	0	10	10
Parker Dam, Calif-Ariz	0	23	23	0	8	8
Columbia River:						
Wenatchee, Wash	1	5	6	0	1	1
Pasco, Wash *	25	163	188	0	1	1
Clatskanie, Ore	10	27	37	0	<1	<1
Connecticut River:						
Enfield Dam, Conn	1	3	4	0	0	0
Cumberland River:						
Cheatham Lock, Tenn	0	4	4	0	0	0
Delaware River:						
Philadelphia, Pa	4	3	7	1	0	1
Great Lakes:						
Duluth, Minn	0	3	3	0	0	0
Green River:						
Dutch John, Utah	<1	15	15	0	3	3
Hudson River:						
Poughkeepsie, N. Y	1	4	5	0	0	0
Illinois River:						
Peoria, Ill	11	14	25	2	3	5
Grafton, Ill	5	11	16	1	1	2
Kansas River:						
DeSoto, Kans	7	19	26	2	3	5
Klamath River:						
Keno, Ore	0	5	5	0	0	0
Maumee River:						
Toledo, Ohio	4	11	15	1	2	3
Mississippi River:						
St. Paul, Minn	2	16	18	0	2	2
E. St. Louis, Ill	17	11	28	5	1	6
New Orleans, La	7	10	17	2	1	3
Missouri River:						
Williston, N. Dak	6	14	20	2	2	4
Bismarck, N. Dak	1	15	16	0	2	2
Yankton, S. Dak	2	24	26	0	3	3
St. Joseph, Mo	11	25	36	2	6	8
Kansas City, Kans	1	24	25	0	4	4
North Platte River:						
Henry, Nebr	2	35	37	<1	20	20
Ohio River:						
Cairo, Ill	2	7	9	0	0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	<1	4	4	0	<1	<1
Platte River:						
Plattsmouth, Nebr	9	24	33	2	8	10
Potomac River:						
Washington, D. C	5	4	9	0	0	0
Rainy River:						
Baudette, Minn	2	11	13	<1	0	<1
Red River, North:						
Grand Forks, N. Dak	6	19	25	1	1	2
Red River, South:						
Alexandria, La	2	14	16	0	1	1
Rio Grande:						
El Paso, Tex	11	15	26	3	4	7
Laredo, Tex	30	13	43	5	4	9
San Joaquin River:						
Vernalis, Calif	1	13	14	0	6	6
San Juan River:						
Shiprock, N. Mex	15	8	23	3	2	5
Savannah River:						
Port Wentworth, Ga *	3	12	15	0	0	0
Snake River:						
Payette, Idaho	1	10	11	0	3	3
Wawawai, Wash	10	4	14	0	0	0
South Platte River:						
Julesburg, Colo	6	72	78	1	58	59
Susquehanna River:						
Conowingo, Md	0	2	2	0	0	0
Tennessee River:						
Chattanooga, Tenn	1	6	7	0	0	0
Wabash River:						
New Harmony, Ind	4	8	12	1	1	2
Yellowstone River:						
Sidney, Mont	18	11	29	6	2	8
Maximum	30	163	188	6	58	59
Minimum	0	2	2	0	0	0

* Gross beta activity at this station may not be directly comparable to gross beta activity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides common to all stations.

1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations are published in annual compliations (*1-6*) or are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During March and April, the following stations showed alpha radioactivity in excess of 15 pCi/liter on dissolved solids:

North Platte River: Henry, Nebraska
Arkansas River: Coolidge, Kansas
South Platte River: Julesburg, Colorado

Ponca City, Oklahoma, on the Arkansas River, dropped below 15 pCi/liter on alpha radioactivity on dissolved solids.

During April, Pasco, Washington, on the Columbia River, showed a beta radioactivity in slight excess of 150 pCi/liter on dissolved solids. At Kingston, Tennessee, on the Clinch River, the average beta radioactivity for the month was less than 150 pCi/liter; however, the sample collected on April 18 yielded 328 pCi/liter.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data. PHS publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

On intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to the programs presented in this issue, the following program was previously covered in *Radiological Health Data and Reports*:

Network	Period	Issue
HASL Fallout Network	July–December 1965	September 1966

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1. Radiation Surveillance Network
June 1966

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analytical procedures was presented in the December 1965 issue of *Radiological Health Data.*

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during June 1966. Time profiles of gross beta in air for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 327 air samples. Fresh fission products were identified in 165 air samples during June 1966, in addition to traces of longer-lived fission products from earlier testing.

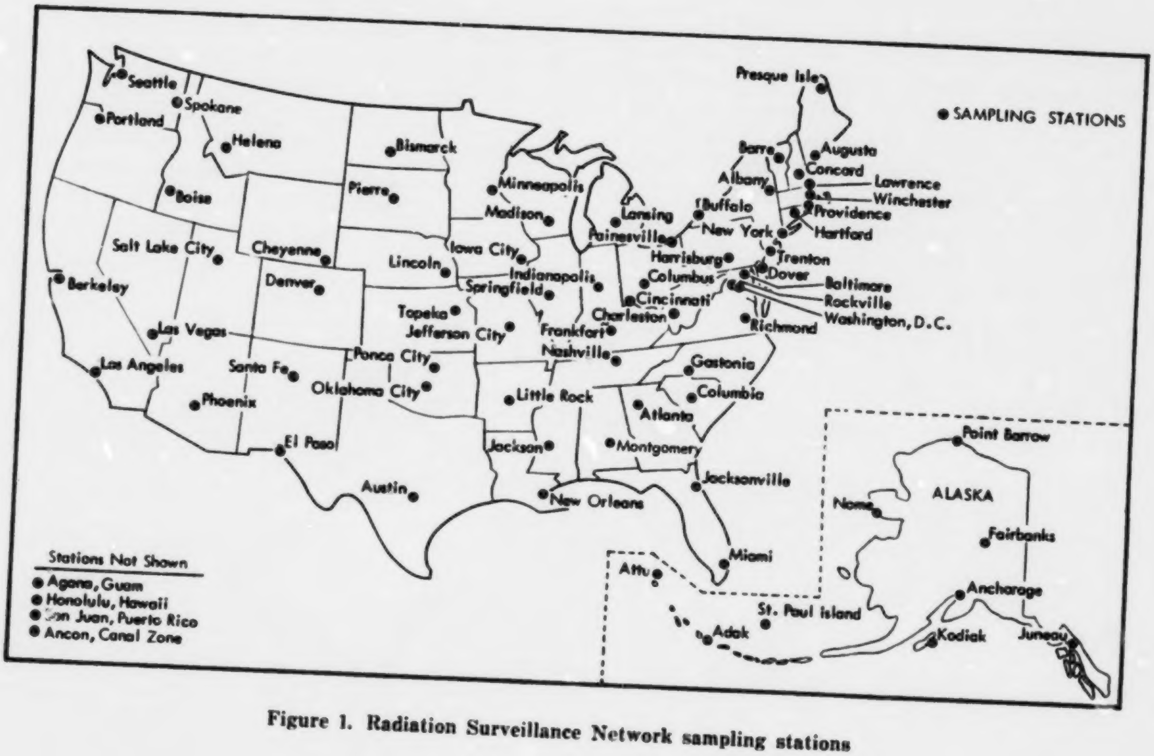

● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Lincoln
Iowa City
Berkeley
Denver
Springfield
Indianapolis
Topeka
Jefferson City
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Phoenix
El Paso
Austin
Little Rock
Jackson
New Orleans
Montgomery
Nashville
Frankfort
Charleston
Cincinnati
Columbus
Lansing
Painesville
Buffalo
Harrisburg
Atlanta
Columbia
Gastonia
Jacksonville
Miami
Presque Isle
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Providence
Hartford
New York
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Kodiak
Juneau
Attu
Adak
St. Paul Island
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta activity in surface air and precipitation, June 1966

Station location		Number of samples		Air surveillance			Last profile in *RHD&R*	Precipitation	
				Gross beta activity, pCi/m³					
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	30	3	0.74	0.15	0.30	Feb 66	71	<20
Alaska:	Adak	30		0.13	<0.10	<0.10	June 66	(c)	
	Anchorage	13	4	0.45	<0.10	<0.16	Mar 66	14	<3
	Attu Island	(b)					July 66	(c)	
	Fairbanks	(b)					Apr 66	(c)	
	Juneau	20	5	0.14	<0.10	<0.10	July 65	32	<6
	Kodiak	6		<0.10	<0.10	<0.10	May 66	(c)	
	Nome	(b)					Sept 66	(c)	
	Point Barrow	30		0.15	<0.10	<0.10	Aug 66	(c)	
	St. Paul Island	29		<0.10	<0.10	<0.10	Jan 66	(c)	
Ariz:	Phoenix	26		1.30	0.24	0.67	July 65	(c)	
Ark:	Little Rock	12		1.08	0.13	0.35	Mar 66	(c)	
Calif:	Berkeley	26	1	0.33	<0.10	<0.12	May 66	2	1
	Los Angeles	21		0.28	<0.10	<0.16	Sept 66	(c)	
C.Z:	Ancon	16		<0.10	<0.10	<0.10	May 66	(c)	
Colo:	Denver	29	7	1.98	<0.10	0.62	May 66	39	<11
Conn:	Hartford	30	9	0.45	<0.10	<0.22	Apr 66	40	<10
Del:	Dover	22		0.56	<0.10	0.24	Feb 66		
D.C.:	Washington	28	5	0.60	<0.10	<0.27	Aug 66	53	<12
Fla:	Jacksonville	30	8	0.69	0.15	0.31	Mar 66	147	<30
	Miami	24	15	1.30	<0.10	0.40	Apr 66	262	<53
Ga:	Atlanta	(b)	5				Oct 66	65	<13
Guam:	Agana	30		0.54	<0.10	<0.23	Feb 66	(c)	
Hawaii:	Honolulu	29		0.52	<0.10	0.26	July 66	(c)	
Idaho:	Boise	29	2	0.48	<0.10	<0.24	July 66	5	5
Ill:	Springfield	29	4	0.53	<0.10	0.27	Aug 66	17	<6
Ind:	Indianapolis	28	4	0.64	<0.10	0.30	Oct 66	37	<10
Iowa:	Iowa City	29	8	0.48	<0.10	<0.23	May 66	171	<46
Kans:	Topeka	30	10	0.59	<0.10	0.28	Mar 66	169	<46
Ky:	Frankfort	27	4	0.79	0.11	0.35	Aug 66	19	<4
La:	New Orleans	30	6	0.74	0.15	0.35	Aug 66	55	<11
Maine:	Augusta	29	9	0.48	<0.10	<0.21	Sept 66	87	<20
	Presque Isle	25	6	0.39	<0.10	<0.17	May 66	31	<6
Md:	Baltimore	22	7	0.60	<0.10	0.35	Apr 66	38	<8
	Rockville Lab	15		0.47	<0.10	<0.27	July 66	(c)	
Mass:	Lawrence	30	8	0.60	<0.10	<0.24	Feb 66	51	<11
	Winchester	28	8	0.39	<0.10	<0.18	June 66	68	<15
Mich:	Lansing	29	7	0.53	<0.10	<0.23	July 66	58	<18
Minn:	Minneapolis	21	10	0.42	<0.10	<0.20	Feb 66	103	<35
Miss:	Jackson	29	2	0.67	0.13	0.29	Sept 66	22	<10
Mo:	Jefferson City	29	5	0.49	<0.10	0.27	Oct 66	57	<18
Mont:	Helena	30	7	0.46	<0.10	<0.25	June 66	27	<9
Nebr:	Lincoln	26	8	1.66	<0.10	<0.34	Jan 66	64	<17
Nev:	Las Vegas	26		1.10	0.28	0.57	Apr 66	(c)	
N.H:	Concord	22		0.73	<0.10	<0.25	Aug 66	(c)	
N.J:	Trenton	30	3	0.46	<0.10	<0.24	Sept 66	4	<1
N. Mex:	Santa Fe	25	8	1.59	0.14	0.68	June 66	34	<10
N.Y:	Albany	21	9	0.83	<0.10	<0.24	Oct 66	57	<12
	Buffalo	30		0.47	<0.10	<0.21	May 66	(c)	
	New York	30		0.37	<0.10	<0.19	June 66	(c)	
N.C:	Gastonia	30	4	0.70	0.16	0.34	May 66	97	<19
N. Dak:	Bismarck	26	9	0.76	<0.10	<0.22	Aug 66	106	<26
Ohio:	Cincinnati	19		0.27	<0.10	<0.18	Feb 66	(c)	
	Columbus	29	5	1.06	0.12	0.53	Sept 66	20	<4
	Painesville	27	5	0.65	<0.10	<0.27	Apr 66	55	<13
Okla:	Oklahoma City	28	1	0.91	<0.10	0.32	July 66	22	<4
	Ponca City	23	5	0.33	<0.10	<0.15	Apr 66	84	<19
Ore:	Portland	30	7	0.61	<0.10	<0.17	Jan 66	23	<5
Pa:	Harrisburg	29		0.43	<0.10	<0.21	Oct 66	(c)	
P.R:	San Juan	25	5	2.34	0.13	0.56	Sept 66	146	<29
R.I:	Providence	27	7	0.34	<0.10	<0.17	July 66	55	<11
S.C:	Columbia	26	5	0.77	<0.10	0.32	June 66	175	<35
S. Dak:	Pierre	30	1	1.65	<0.10	0.32	July 65	3	4
Tenn:	Nashville	29	3	0.64	<0.10	0.27	July 66	29	15
Tex:	Austin	30	5	0.87	0.18	0.39	Feb 66	15	<4
	El Paso	30	6	1.85	<0.10	0.60	Aug 66	47	<10
Utah:	Salt Lake City	28	2	1.51	0.17	0.60	Sept 66	1	2
Vt:	Barre	28	10	0.74	<0.10	<0.25	Mar 66	76	<15
Va:	Richmond	30	8	0.44	<0.10	<0.24	Mar 66	82	<17
Wash:	Seattle	29	8	0.20	<0.10	<0.10	Mar 66	18	<4
	Spokane	30	2	0.46	<0.10	<0.19	Feb 66	4	2
W. Va:	Charleston	28	3	0.71	<0.10	0.29	June 66	8	<2
Wis:	Madison	30	7	0.51	<0.10	<0.19	Mar 66	87	<28
Wyo:	Cheyenne	30	4	2.34	<0.10	0.61	Apr 66	51	<39
Network summary		1,851	309	2.34	<0.10	<0.28		59	<15

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If more than 10 percent of the samples contain <0.10 pCi/m³, a less-than sign is placed before the average.

[b] Indicates no report received.

[c] Indicates no precipitation sample collected.

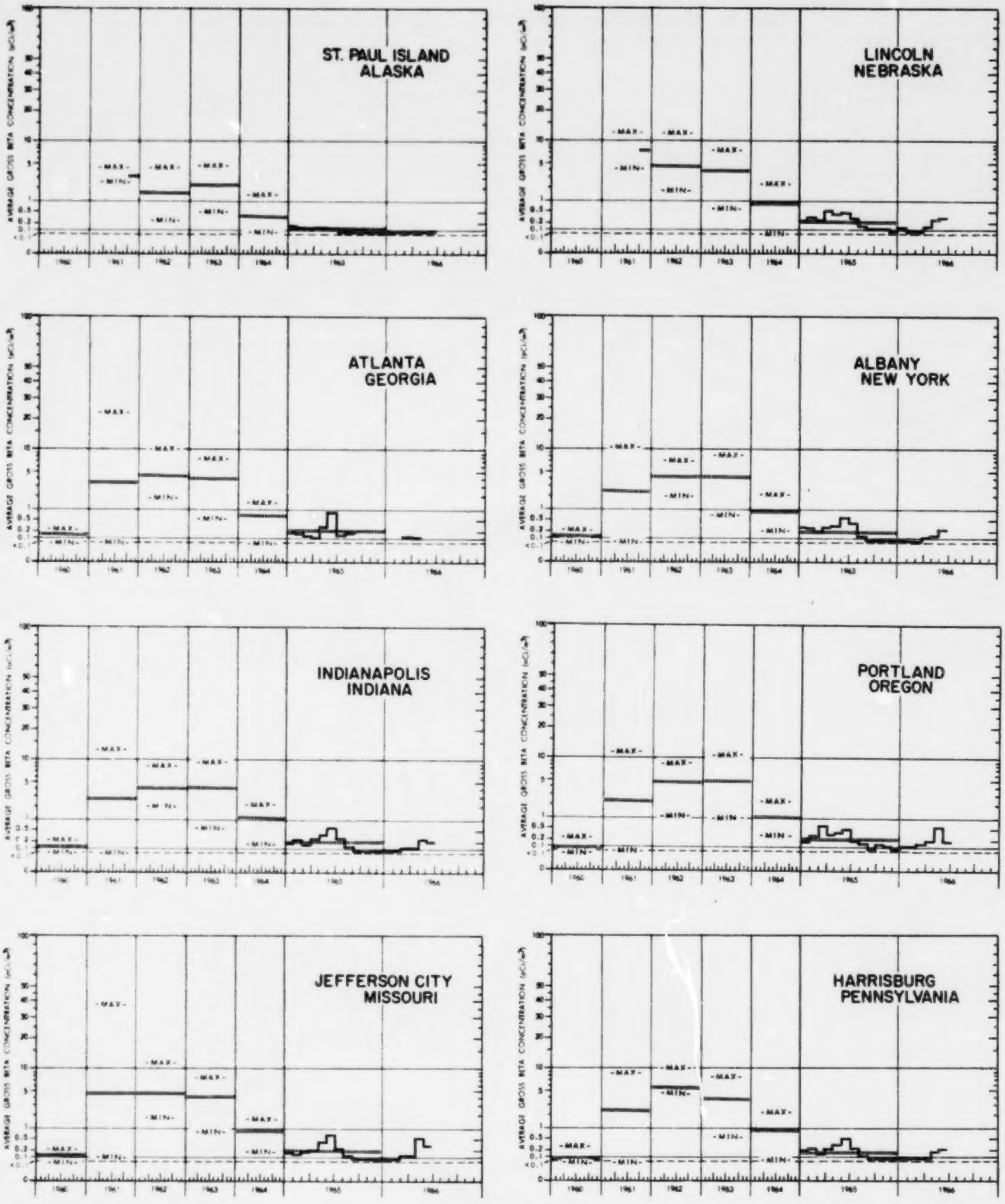


Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1960—June 1966

2. Canadian Air and Precipitation Monitoring Program, June 1966[1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

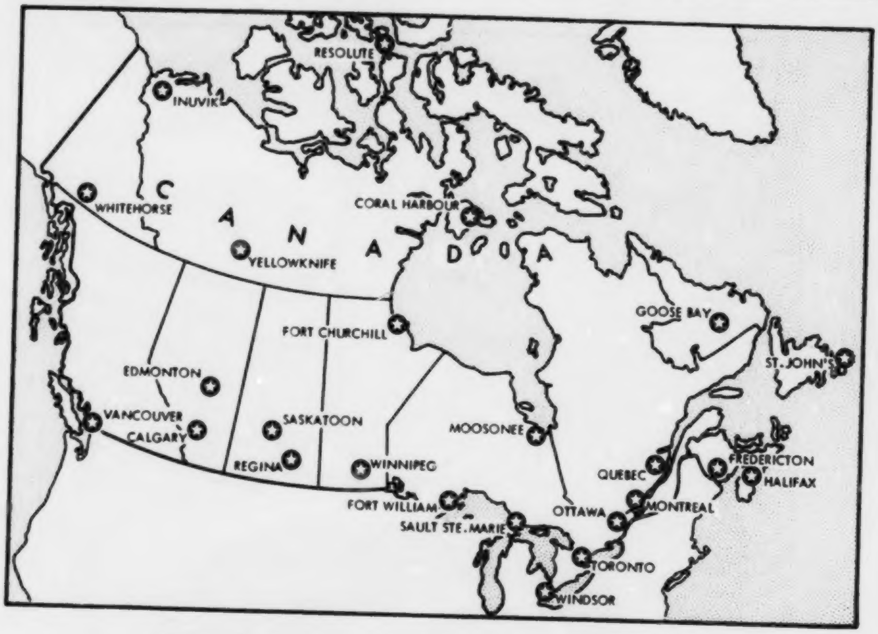
The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data.*

Surface air and precipitation data for June 1966 are presented in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, June 1966

Station	Number of samples	Air surveillance activity, pCi/m³			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.7	0.1	0.2	60	4.8
Coral Harbour	30	0.2	0.0	0.0	44	1.3
Edmonton	30	0.3	0.0	0.1	163	7.9
Ft. Churchill	30	0.2	0.0	0.1	123	4.1
Ft. William	30	0.4	0.0	0.1	150	5.7
Fredericton	30	0.4	0.0	0.2	139	7.2
Goose Bay	23	0.3	0.0	0.1	31	2.9
Halifax	30	0.4	0.0	0.2	62	3.7
Inuvik	30	0.4	0.0	0.1	184	2.2
Montreal	16	0.4	0.1	0.2	55	4.2
Moosonee	29	0.5	0.0	0.1	85	8.6
Ottawa	30	0.8	0.0	0.2	145	8.1
Quebec	30	0.6	0.0	0.2	152	11.4
Regina	30	0.8	0.0	0.2	83	8.9
Resolute	29	0.1	0.0	0.0	37	0.2
St. John's, Nfld	29	0.5	0.0	0.1	39	3.8
Saskatoon	30	0.4	0.0	0.2	102	13.9
Sault Ste. Marie	30	0.5	0.0	0.2	216	12.2
Toronto	30	0.9	0.1	0.3	151	8.3
Vancouver	30	0.4	0.0	0.1	75	3.9
Whitehorse	30	0.6	0.0	0.2	89	3.3
Windsor	29	0.7	0.1	0.3	129	12.6
Winnipeg	30	0.6	0.0	0.2	160	5.7
Yellowknife	30	0.3	0.0	0.2	97	3.1
Network summary		0.9	0.0	0.2	107	6.2


RESOLUTE
INUVIK
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WHITEHORSE
YELLOWKNIFE
CORAL HARBOUR
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
FREDERICTON
HALIFAX
QUEBEC
FORT WILLIAM
MONTREAL
OTTAWA
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the July 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Mexican Air Monitoring Program March and April 1966

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México City. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. In 1966, the Division of Radiological Protection was restructured and its name changed to General Direction of Radiological Security (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de Mexico, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- x 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via air mail to the Sección de Radioactividad Ambiental, CNEN, in Mexico City for assay of gross beta activity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data is not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month was needed to get a reliable average of activity in each station (*8*).

The maximum, minimum, and average fission product beta concentrations in surface air during March and April 1966 are presented in tables 3 and 4.

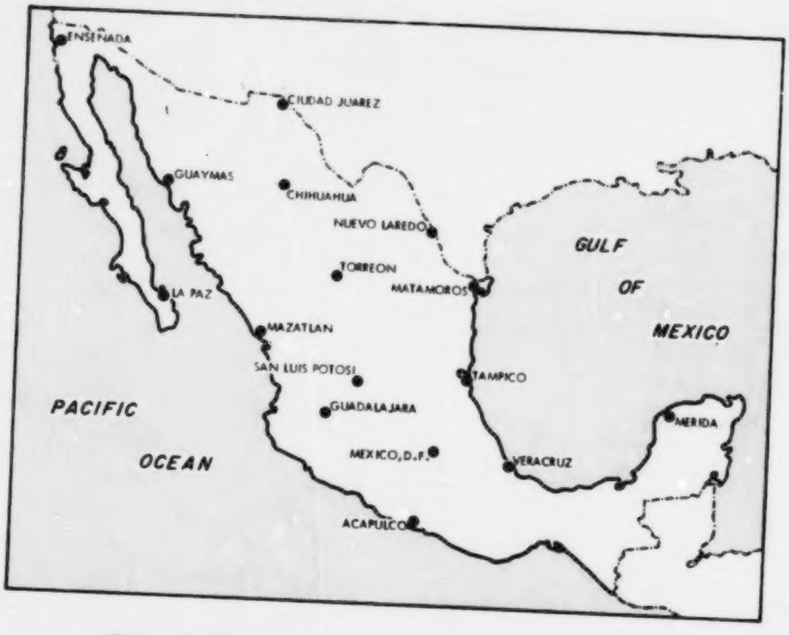

Figure 4. Mexican air sampling station locations

Table 3. Mexican gross beta activity of airborne particulates March 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	NS			
Ciudad Juárez	10	0.4	0.1	0.3
Chihuahua	10	0.5	0.1	0.3
Ensenada	11	0.4	0.1	0.2
Guadalajara	3	0.2	0.1	
Guaymas	7	0.5	0.1	0.2
La Paz	11	0.7	0.1	0.3
Matamoros	9	0.6	0.1	0.3
Mazatlán	10	0.5	0.1	0.3
Mérida	12	0.6	0.1	0.3
México, D.F.	18	0.7	0.1	0.2
Nuevo Laredo	10	0.4	0.1	0.3
San Luis Potosí	6	0.2	0.1	0.1
Tampico	6	0.2	0.1	0.1
Torreón	15	0.4	0.1	0.3
Tuxtla Gutiérrez [a]				
Veracruz	13	0.5	0.1	0.3

[a] Sampling discontinued February 1966 at Tuxtla Gutierrez.
NS, no sample collected: station temporarily shutdown.

Table 4. Mexican gross beta activity of airborne particulat April 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	4	0.1	0.1	0.1
Ciudad Juárez	15	0.5	0.1	0.2
Chihuahua	8	0.5	0.1	0.2
Ensenada	2	0.1	0.1	0.1
Guadalajara	NS			
Guaymas	1	0.5	0.5	0.5
La Paz	14	0.4	0.1	0.2
Matamoros	4	0.2	0.1	0.1
Mazatlán	12	0.3	0.1	0.2
Mérida	7	0.5	0.1	0.2
México, D.F.	1	0.1	0.1	0.1
Nuevo Laredo	4	0.2	0.1	0.2
San Luis Potosí	6	0.5	<0.1	0.2
Tampico	10	0.2	<0.1	0.1
Torreón	10	0.2	<0.1	0.2
Veracruz	15	0.3	0.1	0.2

NS, no sample collected: station temporarily shut down.

4. Pan American Air Sampling Program June 1966

Pan American Health Organization and *U.S. Public Health Service*

Gross beta activity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station locations are shown in figure 5.

Table 5. PAHO gross beta activity in surface air, June 1966

Station location	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	16	0.14	<0.10	<0.10
Chile: Santiago	26	<0.10	<0.10	<0.10
Ecuador: Guayaquil [b]	9	<0.10	<0.10	<0.10
Jamaica: Kingston	25	0.80	<0.10	<0.30
Peru: Lima	17	<0.10	<0.10	<0.10
Venezuela: Caracas	16	0.32	<0.10	<0.12
West Indies: Trinidad	21	0.35	<0.10	<0.18
Pan American summary	130	0.80	<0.10	<0.14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If more than 10 percent of the samples contain <0.10 pCi/m³, a less-than sign is placed before the average.
[b] Guayaquil, Equador, began reporting data in June 1966.

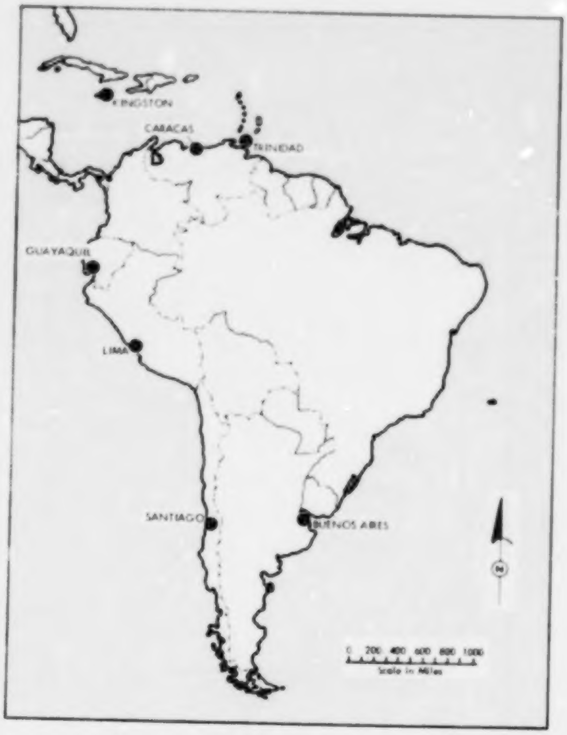

Figure 5. Pan American Air Sampling Program stations

The June 1966 air monitoring results from the participating countries are given in table 5.

5. National Air Sampling Network April–June 1966

Division of Air Pollution
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. One of the many analyses performed by the NASN on their air samples is for gross beta radioactivity. NASN stations (figure 6) are manned by cooperating Federal, State, and local agencies. The network consists of 110 sampling stations which operation every year and 130 stations which operate every other year. A description of the sampling network was presented in the December 1965 issue of *Radiological Health Data*. Second quarter 1966 gross beta activities in air are given in table 6.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Annual summary 1964	April 1965
Annual summary 1965	April 1966
January–March 1966	July 1966

REFERENCES

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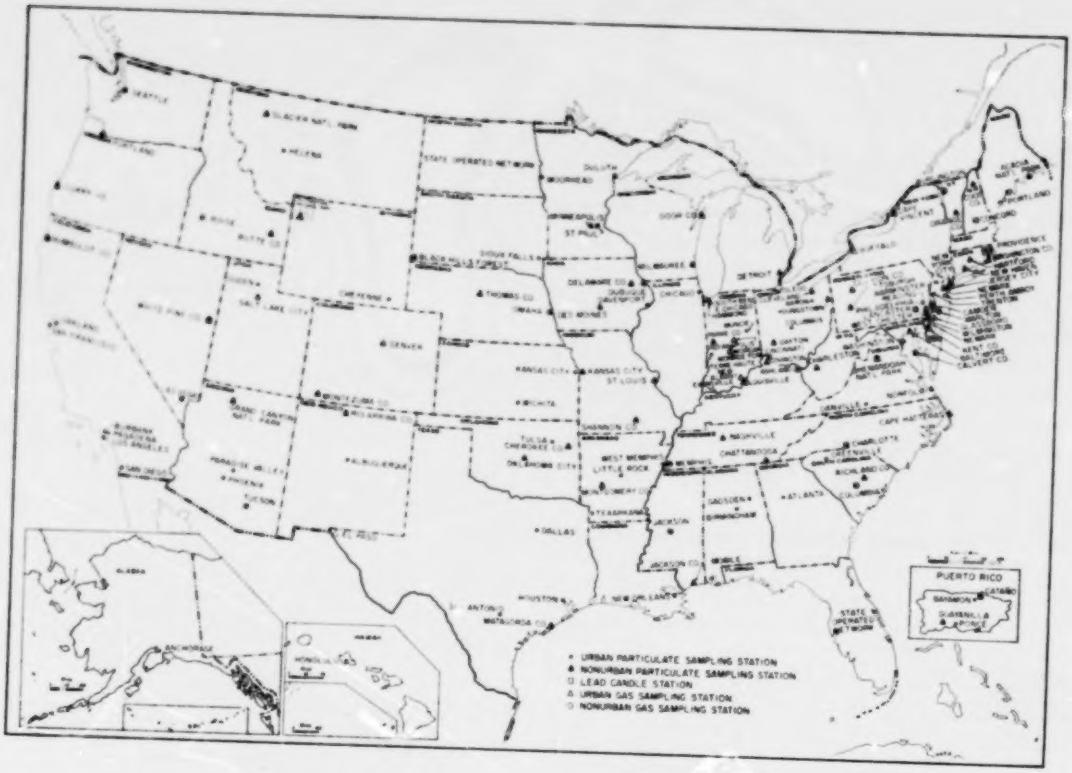
URBAN PARTICULATE SAMPLING STATION
NONURBAN PARTICULATE SAMPLING STATION
LEAD CANDLE STATION
URBAN GAS SAMPLING STATION
NONURBAN GAS SAMPLING STATION
PUERTO RICO
ALASKA
HAWAII

Figure 6. National Air Sampling Network locations, 1966

Table 6. NASN fission product gross beta activity in surface air, April–June 1966

Station name		Number of samples	Concentration, pCi/m³		
			Maximum	Minimum	Average
Ariz:	Paradise Valley	7	10.8	0.1	1.9
	Phoenix	7	7.4	0.2	1.5
	Tucson	7	4.7	0.2	1.1
Ark:	Little Rock	7	1.2	0.1	0.4
	Montgomery County *	7	0.5	0.1	0.3
	Texarkana	6	0.5	0.1	0.3
	West Memphis	6	1.5	0.1	0.5
Calif:	Burbank	7	1.4	0.1	0.3
	Humboldt County *	7	0.2	<0.1	0.1
	Los Angeles	7	4.6	0.1	0.9
	Oakland	7	0.3	0.1	0.2
	Pasadena	7	1.9	0.1	0.5
	San Diego	6	2.2	0.1	0.5
	San Francisco	7	0.4	0.1	0.2
Colo:	Denver	7	1.3	0.2	0.5
	Montezuma County *	7	5.3	0.2	1.3
Conn:	Hartford	7	0.5	<0.1	0.3
	New Haven	7	0.4	<0.1	0.2
Del:	Kent County *	7	0.6	<0.1	0.3
	Newark	6	0.5	0.2	0.3
	Wilmington	6	1.8	0.1	0.5
D. C:	Washington	7	0.6	<0.1	0.2
Ga:	Atlanta	6	1.0	0.1	0.5
Hawaii:	Honolulu	7	1.8	<0.1	0.4
Idaho:	Boise	7	0.6	0.1	0.3
	Butte County *	7	0.8	0.1	0.4
Ill:	Chicago	7	0.6	0.1	0.2
Ind:	East Chicago	7	0.6	0.1	0.3
	Hammond	5	0.5	0.1	0.3
	Indianapolis	7	0.8	0.1	0.3
	N. Monroe State Forest	6	0.5	0.1	0.3
	Muncie	7	0.5	0.1	0.3
	New Albany	6	0.8	<0.1	0.3
	Parke County *	7	0.7	0.1	0.2
	South Bend	7	0.5	0.1	0.3
	Terre Haute	7	0.7	0.1	0.3
Iowa:	Davenport	6	0.8	0.1	0.3
	Delaware County *	7	0.4	0.1	0.2
	Des Moines	7	0.5	0.1	0.2
	Dubuque	7	0.4	0.1	0.2
Kans:	Kansas City	5	0.3	0.2	0.2
	Wichita	7	0.6	0.1	0.3
Ky:	Ashland	7	0.6	0.1	0.3
	Covington	7	0.9	0.1	0.4
	Louisville	7	0.7	0.1	0.3
La:	New Orleans	7	1.4	0.1	0.4
Maine:	Acadia National Park *	6	0.3	0.1	0.2
	Portland	5	0.3	0.1	0.2
Md:	Baltimore	7	0.5	0.1	0.3
	Calvert County *	7	0.4	0.1	0.2
Mich:	Detroit	7	0.5	0.1	0.3
Minn:	Duluth	7	0.5	0.1	0.2
	Minneapolis	7	0.5	0.1	0.2
	Moorhead	7	0.4	0.1	0.2
	St. Paul	6	0.4	<0.1	0.2
Miss:	Jackson	7	0.7	0.1	0.3
	Jackson County *	7	1.1	0.1	0.4
Mo:	Kansas City	7	0.4	0.1	0.2
	St. Louis	6	0.6	0.1	0.3
	Shannon County *	6	0.9	0.1	0.3
Mont:	Glacier National Park *	7	0.9	0.1	0.3
	Helena	7	1.1	0.1	0.3
Nebr:	Omaha	7	0.4	0.1	0.2
	Thomas County *	7	0.8	0.1	0.2
Nev:	Las Vegas	7	5.9	0.1	1.3
	White Pine County *	6	8.6	0.1	1.6

Station name		Number of samples	Concentration, pCi/m³		
			Maximum	Minimum	Average
N. H:	Concord	7	0.8	<0.1	0.3
	Coos County *	6	0.4	0.2	0.3
N. J:	Marlton	7	0.5	0.1	0.3
	Camden	7	0.4	<0.1	0.2
	Glassboro	7	0.5	0.1	0.3
	Jersey City	6	0.6	0.1	0.3
	Newark	7	0.4	<0.1	0.2
	Perth Amboy	6	0.5	0.1	0.3
	Trenton	5	0.3	0.1	0.2
N. Mex:	Albuquerque	7	3.5	0.2	1.0
	Rio Arriba County *	7	1.9	0.2	0.6
N. Y:	Cape Vincent *	7	0.4	0.1	0.2
	New York City	7	0.6	0.1	0.3
N. C:	Charlotte	7	0.8	0.1	0.3
	Cape Hatteras *	5	0.6	0.1	0.3
Ohio:	Akron	7	0.9	0.1	0.4
	Cincinnati	7	0.5	0.1	0.3
	Cleveland	7	0.7	0.1	0.4
	Columbus	7	0.8	0.1	0.4
	Dayton	7	1.1	<0.1	0.4
	Toledo	7	0.8	0.1	0.4
	Youngstown	7	0.8	0.1	0.3
Okla:	Cherokee County *	7	0.5	0.1	0.3
	Oklahoma City	7	0.7	0.3	0.5
	Tulsa	7	0.9	0.2	0.5
Ore:	Curry County *	5	0.2	0.1	0.1
	Portland	6	0.1	<0.1	0.1
Pa:	Clarion County *	6	0.4	0.1	0.2
	Lancaster	7	0.9	0.1	0.4
	Philadelphia	6	0.6	<0.1	0.3
	Pittsburgh	7	0.6	<0.1	0.3
	Reading	7	0.7	<0.1	0.3
	Warminster	7	0.5	<0.1	0.2
	West Chester	7	0.7	<0.1	0.3
P. R:	Bayamón	7	0.7	0.1	0.3
	Guayanilla	7	1.1	0.1	0.3
	Ponce	7	0.5	0.1	0.2
	San Juan	7	1.6	0.1	0.4
R. I:	Providence	6	0.5	0.1	0.3
	Washington County *	5	0.4	0.1	0.3
S. C:	Columbia	7	0.8	0.1	0.3
	Greenville	7	0.6	0.1	0.3
	Richland County *	7	0.4	0.2	0.3
S. Dak:	Black Hills Forest *	6	0.6	0.1	0.3
	Sioux Falls	7	1.8	0.1	0.5
Tenn:	Chattanooga	7	0.7	0.2	0.4
	Memphis	7	0.9	0.1	0.4
	Nashville	6	0.5	0.1	0.4
Tex:	Dallas	7	0.8	0.1	0.4
	Houston	7	1.0	0.1	0.3
	Matagorda County *	6	1.2	0.1	0.4
	San Antonio	7	0.8	0.1	0.3
Utah:	Ogden	7	0.9	0.1	0.4
	Salt Lake City	7	1.9	0.1	0.6
Vt:	Burlington	7	0.9	0.1	0.3
	Orange County *	7	0.6	0.1	0.3
Va:	Danville	7	1.4	<0.1	0.5
	Norfolk	5	0.2	0.1	0.1
	Shenandoah Nat'l Park *	7	0.4	<0.1	0.2
Wash:	Seattle	7	0.3	0.1	0.2
W. Va:	Charleston	6	0.5	0.1	0.3
Wis:	Door County *	5	0.2	0.1	0.1
	Milwaukee	7	0.7	0.1	0.3
Wyo:	Cheyenne	7	1.1	0.1	0.5
	Yellowstone Park *	7	1.7	0.1	0.5

* Denotes nonurban station.

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Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

STRONTIUM-90 IN HUMAN BONE SAMPLES, JULY-SEPTEMBER 1965[1]

Division of Radiological Health
Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium–90 in measurable amounts has been present in the global environment for more than a decade and major calcium accretion ceases by age 17 or 18, persons over 25-years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium–90 content to be low and age-independent (*1*).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available for older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for comparison of results with British data have not been successful.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Division of Radiological Health, Winchester, Massachusetts. Sample collection and preparation are explained elsewhere (*2*). Strontium–90 is measured by TBP extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium–90 content is then calculated (*3*) from the yttrium–90 activity. For the purpose of maintaining analytical quality control, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. In addition, pools of animal bone ash and adult human bone ash are analyzed in replicate on a continuing basis.

The results of laboratory analyses for strontium–90 in individual bones from persons dying during the third quarter of 1965 are presented in table 1, in order of increasing age within each sampling region. The sampling regions have been defined in an earlier report (*5*). The data are reported as picocuries of strontium–90 per gram of ash (the primary determination) per gram of calcium (for comparison with other data and for purposes of model development) and per gram of bone (as a rough indication of dose). Two-sigma counting errors are reported for the ash concentration. Table 2 summarizes

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[1] Period during which death occurred.

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Table 1. Strontium-90 in human bone, deaths during July–September 1965

Location of sample by region and State	Sex	Bone type [a]	Age at death [b] (years)	Strontium-90, pCi/g of: Ash	2 σ error	Ca	Bone
Northeast:							
N. Y.	M	V	2	1.05	0.10	2.82	0.08
N. Y.	M	V	2	1.73	0.18	5.19	0.10
Mass.	M	V	3	1.87	0.11	5.26	0.19
N. Y.	M	V	4	0.91	0.16	2.70	0.05
Mass.	M	V	4	1.30	0.11	3.64	0.13
N. Y.	F	V	4	0.83	0.12	2.40	0.05
N. Y.	F	V	5	0.81	0.11	2.23	0.06
Mass.	F	V	7	1.83	0.12	5.25	0.18
Mass.	M	V	7	0.80	0.08	2.20	0.08
Mass.	F	V	10	0.79	0.07	2.21	0.08
Mass.	M	V	11	1.03	0.07	2.92	0.11
N. Y.	M	V	12	0.99	0.11	2.56	0.11
Vt.	M	V	16	1.00	0.07	2.66	0.15
Pa.	M	V	17	0.91	0.06	2.32	0.16
Mass.	M	V	18	0.97	0.06	2.51	0.11
Pa.	M	V	18	0.84	0.07	2.18	0.12
Mass.	M	V	19	0.82	0.07	2.17	0.13
Vt.	M	V	19	1.20	0.07	3.24	0.18
N. Y.	M	V	19	1.02	0.10	2.70	0.12
Pa.	M	V	19	0.72	0.12	1.85	0.13
Vt.	M	V	19	0.90	0.07	2.31	0.13
N. Y.	F	V	19	0.60	0.07	1.57	0.07
Vt.	M	V	19	1.11	0.08	2.95	0.13
Mass.	F	V	24	0.68	0.06	1.73	0.08
N. Y.	M	V	25	0.50	0.05	1.31	0.07
Vt.	M	V	25	0.69	0.05	1.84	0.09
Central:							
Minn.	F	V	4	0.99	0.09	2.76	0.09
Ohio	M	V	4	0.92	0.12	2.44	0.13
Ohio	M	V	5	0.99	0.09	2.55	0.17
Wis.	F	V	5	0.87	0.11	2.45	0.07
Ohio	M	V	6	0.87	0.10	2.31	0.09
Ohio	M	V	10	0.74	0.09	1.94	0.11
Wis.	M	V	10	0.81	0.07	2.27	0.08
Ohio	M	V	12	0.69	0.08	1.86	0.06
Minn.	M	V	15	1.38	0.12	3.83	0.10
Ohio	M	V	16	1.09	0.07	2.85	0.17
Ohio	F	V	17	0.52	0.19	1.31	0.09
Minn.	F	V	18	0.67	0.08	1.75	0.06
Ohio	M	V	21	0.73	0.06	1.91	0.13
Ohio	M	V	22	0.69	0.03	1.83	0.08
Ohio	M	V	23	0.63	0.06	1.64	0.13
Ohio	M	V	25	0.47	0.05	1.20	0.08
Delta:							
La.	F	V	2	2.43	0.14	6.56	0.29
La.	F	V, R	4	1.35	0.11	3.56	0.15
La.	F	V, R	5	1.64	0.11	4.38	0.20
La.	F	V, R	11	0.41	0.11	1.09	0.04
Southwest:							
Calif.	M	V, R, A, I, F	0 (sb)[c]	0.26	0.03	0.69	0.03
Calif.	M	A, F, I	0 (sb)[c]	0.41	0.05	0.11	0.04
Calif.	M	A, F	0 (1 day)	0.31	0.05	0.81	0.04
Calif.	F	V, R, I	0 (7 day)	0.48	0.08	1.28	0.03
Tex.	M	V	1	2.74	0.22	7.77	0.27

[a] Type of bone:
V, vertebrae
R, rib
F, femur
I, ilium
A, arm

[b] Age given as of last birthday prior to death.

[c] Stillborn.

all data from 1961 through the third quarter 1965.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–4*).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Deaths through 1964	April 1966
First Quarter 1965	June 1966
Second Quarter 1965	September 1966

Table 2. Strontium-90 in human bone samples for 5-year-age groups, 1961–1964, and January–September 1965

Age group [a]	Year at death [b]	Number	Strontium-90, pCi/g calcium		
			Mean [c]	Minimum	Maximum
0–4 years	1961	3	2.7	1.8	3.4
	1962	50	3.3	0.8	9.7
	1963	44	4.5	1.0	13.0
	1964	67	4.4	1.0	8.7
	1965, January–September	53	3.9	0.7	8.9
5–9 years	1961	1	2.7	—	—
	1962	33	2.7	1.0	9.4
	1963	43	3.9	1.8	9.1
	1964	64	3.6	1.2	7.0
	1965, January–September	33	3.0	1.3	6.4
10–14 years	1961	4	1.8	1.2	2.8
	1962	28	2.1	0.8	3.5
	1963	47	2.9	1.1	9.0
	1964	56	3.1	0.9	5.7
	1965, January–September	31	2.8	1.1	5.2
15–19 years	1961	0	—	—	—
	1962	31	2.2	0.9	4.6
	1963	73	2.6	1.0	7.0
	1964	58	2.9	1.2	8.0
	1965, January–September	43	2.3	1.3	4.7
20–24 years	1961	0	—	—	—
	1962	29	1.8	0.9	3.5
	1963	61	2.2	0.9	5.0
	1964	52	2.2	0.8	4.3
	1965, January–September	29	1.9	1.0	2.8

[a] Age given as of last birthday prior to death; ages greater than 24 years not included.

[b] Or surgical procedure.

[c] Mean values in this table for the various years within each age group may not be directly comparable because of variations in sampling locations from year to year. However, the data are given as a summary of presently available bone results.

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(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64-1. Winchester, Mass. 01890 (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone. Radiol Health Data 5:620–628 (December 1964).

(*5*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Strontium-90 in human bone, October 1964–March 1965. Radiol Health Data 6:397–401 (July 1965).

IODINE-131 IN BOVINE THYROIDS, JULY-DECEMBER 1965

Division of Radiological Health
Public Health Service

To supplement its existing environmental surveillance systems, the Division of Radiological Health established a Bovine Thyroid Network in October 1964 (*1*). Specimens are collected by the Meat Inspection Division, U.S. Department of Agriculture, and analyzed for iodine–131 content at the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

The network consists of collection areas (figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants, and nuclear test sites. Details of sampling and analysis have been published earlier (*1*). For this report, the collection areas (counties) sampled during July through December 1965, were grouped also on a broad geographical basis (figure 1).

The results for July through December 1965, appear in table 1 and are listed chronologically within the geographical groupings in figure 1. The influx of fallout iodine–131 following the mainland China atmospheric nuclear detonation of May 14, 1965, was observed to be generally low (<150 pCi/g thyroid) through July 1965, declining to barely detectable levels in late July 1965. Over the period September 13–14, iodine–131 was observed in several samples collected from counties in California in the Los Angeles area (Fresno, Merced, San Joaquin, Santa Clara) at levels between 50 and 200 pCi/g thyroid. It is suspected that these levels were the result of a release at that time from one of the western nuclear facilities. The observed thyroid activities represent isolated instances which, when evaluated from a public health standpoint, simply indicate the intrusions of low levels of radioactivity into the environment.

REFERENCE

(*1*) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine–131 in bovine thyroid, October-December 1964. Radiol Health Data 6:573–578 (October 1965).

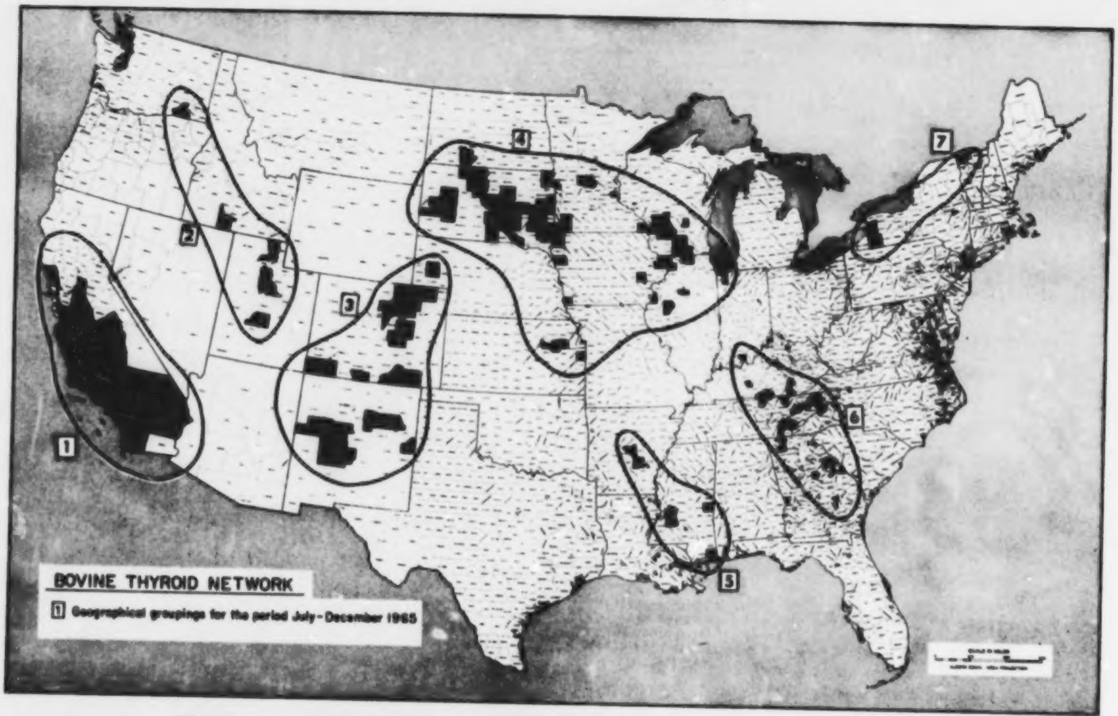

Figure 1. Counties sampled in bovine thyroid network, July-December 1965

Table 1. Iodine-131 in bovine thyroids, July–December 1965

Geographical grouping [a]	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
1 California	7/1	Sacramento	1	38		
		Santa Barbara	2	10	8	12
	7/2	San Joaquin	2	25	21	29
	7/6	Riverside	2	[b] ND		
		Santa Barbara	4	2	ND	3
	7/7	Kern	2	33	21	41
		Los Angeles	1	45		
		San Benito	2	9	8	9
		Santa Clara	2	16	14	17
		Tulare	1	4		
	7/8	Kern	1	8		
		San Joaquin	2	18	12	24
		Stanislaus	1	ND		
	7/9	Merced	1	2		
		Orange	1	30		
		San Bernardino	1	ND		
	7/12	Los Angeles	1	5		
		Madera	4	6	5	7
		Merced	2	9	7	11
		Stanislaus	1	7		
	7/13	Los Angeles	2	ND		
		Merced	1	15		
		San Joaquin	2	16	14	18
	7/14	Kern	1	41		
		Los Angeles	1	3		
		Tulare	1	ND		
	7/15	Ventura	1	6		
	7/16	Orange	2	3	3	3
	7/19	Santa Barbara	1	74		
	7/20	Riverside	3	51	42	58
	7/21	Los Angeles	1	31		
		San Joaquin	2	3	2	4
		Stanislaus	2	1	ND	2
		Tulare	1	2		
	7/22	Fresno	2	3	2	3
		Merced	2	3	2	3
		Tulare	1	ND		
	7/23	Los Angeles	1	ND		
		Orange	1	ND		
	7/26	Los Angeles	1	ND		
		San Benito	2	5	3	6
	7/27	Los Angeles	2	3	ND	6
		Merced	1	3		
		Monterey	2	2	ND	3
		Riverside	1	2		
		San Joaquin	1	4		
	7/28	Los Angeles	1	2		
		San Joaquin	4	<1	ND	4
		Tulare	1	5		
	7/29	Tulare	3	<1	ND	2
	8/2	Madera	2	7	4	10
		Merced	2	2	ND	3
	8/3	Los Angeles	1	ND		
		Madera	2	2	ND	4
		San Joaquin	4	<1	ND	6
	[c] 8/4–9/10	[California] [d] Fresno (8) [f] Kern (1) Kings (2) Los Angeles (26) Madera (4) Merced (17) Monterey (3) Orange (10) Riverside (4) Sacramento (3) San Benito (2) San Joaquin (13) Santa Barbara (8) San Luis Obispo (4) Sonoma (3) Stanislaus (5) Tulare (9)	122	[e] ND		
	9/13	Fresno	2	90	ND	179
		Merced	2	103	ND	206
		Santa Barbara	2	ND		
		San Joaquin	2	28	ND	55
	9/14	Los Angeles	2	ND		
		Merced	2	ND		
		Santa Clara	2	95	3	186
	[c] 9/15–12/30	[California] [d] Fresno (25) [f] Kings (2) Los Angeles (59) Madera (9) Merced (30) Monterey (16) Orange (4) Riverside (15) Sacramento (11) San Benito (2) San Bernardino (1) San Diego (1) San Joaquin (38) San Luis Obispo (1) Santa Barbara (2) Santa Clara (2) Sonoma (3) Stanislaus (11) Tulare (23)	255	[e] ND		

See footnotes at end of table.

Table 1. Continued—Iodine-131 in bovine thyroids, July–December 1965

Geographical grouping [a]	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
2 Washington, Idaho, and Utah	7/7	Utah	1	60		
	7/10	Utah	2	91	51	131
	7/15	Salt Lake	1	19		
		Utah	1	70		
	7/22	Utah	3	9	[b] ND	17
		Weber	2	4	2	5
	8/3	Walla Walla	10	5	ND	13
	8/10	Walla Walla	5	2	ND	3
	8/20	Walla Walla	6	1	ND	3
	[c] 8/23–12/16	[Utah] [d] Cache (5) [f] Salt Lake (5) Sevier (5) Utah (10) Weber (10) [Idaho] Twin Falls (5) [Washington] Walla Walla (39)	79	[e] ND		
3 Colorado, New Mexico, and western Nebraska	7/1	Boulder	1	49		
	7/2	Logan	1	22		
	7/6	Bernalillo	6	19	3	55
	7/7	Bernalillo	2	8	6	10
	7/12	Montezuma	4	100	41	146
	7/14	Bernalillo	4	10	3	22
	7/19	Curry	4	81	6	149
	7/20	Bernalillo	4	38	2	119
	7/26	Bernalillo	4	3	ND	7
	7/27	Valencia	4	4	ND	8
	8/2	Adams	4	4	2	5
		Bernalillo	4	2	ND	4
	8/4	Curry	4	9	3	12
	8/9	La Plata	4	3	2	3
	8/10	Las Animas	1	5		
	[c] 8/12–12/28	[Colorado] [d] Adams (0) [f] Boulder (0) Conejas (8) Denver (2) El Paso (12) Jefferson (1) La Plata (27) Las Animas (0) Logan (16) Montezuma (8) Morgan (2) Weld (2) [New Mexico] Bernalillo (47) Curry (39) San Miguel (13) Socorro (4) Valencia (9) [Nebraska] Morrill (36)	226	[e] ND		
4 North Dakota, South Dakota, Minnesota, Iowa, Illinois, Wisconsin, Kansas, and northwest Indiana	7/8	Sioux	9	22	ND	116
	7/13	Dewey	10	60	3	132
	7/22	Deuel	2	38	36	39
	7/23	Turner	1	ND		
	7/30	Sauk	3	5	3	7
		Nobles	6	3	ND	7
	8/6	Brookings	4	ND		
	8/11	Charles Mix	1	2		
		Hanson	5	1	ND	2
		Lake	4	3	ND	8
	[c] 8/17–12/29	[South Dakota] [d] Aurora (9) [f] Beadle (1) Brookings (19) Brown (18) Brule (1) Buffalo (1) Charles Mix (0) Corson (11) Deuel (2) Dewey (0) Faulk (1) Hamlin (9) Hand (7) Hanson (1) Hughes (1) Hyde (1) Jerwauld (2) Kingsbury (5) Lake (0) Lincoln (1) Lyman (1) McCook (3) Meade (1) Miner (4) Minnehaha (17) Pennington (1) Roberts (2) Sully (5) Tripp (1) Turner (0) [North Dakota] Grant (2)	265	[e] ND		

See footnotes at end of table.

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Table 1. Continued—Iodine-131 in bovine thyroids, July–December 1965

Geographical grouping [a]	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
4 continued.	8/17-12/29	[Indiana] [d] Porter (2) [f] [Minnesota] Big Stone (2) Houston (1) Murray (1) Nobles (0) Ramsey (6) Rock (1) Stearns (2) [Kansas] Geary (2) Miami (1) Shawnee (15) Wabaunsee (1) [Wisconsin] Dane (18) Green (6) Green Lake (1) Juneau (1) Monroe (3) Richland (3) Rock (34) Sauk (7) Vernon (1) [Illinois] Boone (2) Carroll (6) Fulton (5) Henderson (1) Jo Davies (1) Marshall (1) Winnebago (1) [Iowa] Fremont (9) Jackson (1) Johnson (1) Lyon (1) Sioux (0) Woodbury (1)				
5 Arkansas and Mississippi.	7/30	Pulaski	3	7	4	12
	8/10	Jefferson	1	4		
		Pulaski	1	2		
	[c] 8/11-12/15	[Mississippi] [d] Copiah (3) [f] Hinds (5) Jackson (15) Lauderdale (5) [Arkansas] Jefferson (0) Pulaski (0)	28	[e] ND		
6 Tennessee, Kentucky, Georgia, southern Indiana, and western North Carolina	7/13	Clay	1	14		
	7/14	Hawkins	1	12		
		Jefferson	2	22	17	27
	7/29	Richmond	3	3	3	3
	7/30	Greene	1	11		
	8/3	Hawkins	5	9	7	10
	8/4	Jackson	1	3		
	8/5	Richmond	2	5	4	5
	8/6	Putman	2	[b] ND		
	8/9	Bradley	1	ND		
	8/10	Edmonson	4	4	ND	7
	8/13	Greene	3	4	ND	10
	8/23	Greene	2	4	ND	8
	[c] 8/25-10/4	[Tennessee] [d] Bradley (0) [f] Clay (1) Greene (4) Hawkins (1) Jackson (0) Jefferson (0) Knox (2) McMinn (2) Meigs (1) Monroe (7) Scott (1) [Kentucky] Clinton (1) Cumberland (2) Edmonson (1) Laurel (1) Monore (1) Whitley (1) [Indiana] Crawford (1) [North Carolina] Madison (1) [Georgia] Gordon (1) Lincoln (1) McDuffie (1) Montgomery (1) Murray (2) Putman (3) Richmond (1) Wilkes (5)	43	[e] ND		
7 New York and Vermont.	7/13	Franklin	19	12	ND	43
	7/22	Cattaraugus	4	13	8	17
	7/26	Franklin	10	13	7	23
	7/27	Franklin	10	<1	ND	3
	7/29	Cattaraugus	7	9	5	15
	8/5	Cattaraugus	5	2	ND	5
	8/9	Franklin	20	1	ND	3
	8/12	Cattaraugus	8	3	ND	4
	8/19	Cattaraugus	4	2	ND	4
	[c] 8/23-12/28	[Vermont] [d] Franklin (166) [f] [New York] Cattaraugus (43) Erie (36)	245	[e] ND		

[a] Geographical areas as designated in figure 1, encompassing those counties that were sampled in the States indicated.

[b] ND-Not detectable; the two standard deviation counting error was greater than or equal to the concentration observed. For the counting system utilized, the two standard deviation counting errors were generally 1–3 pCi/g thyroid.

[c] Samples were not collected on all dates included during this period, but the interval brackets several sampling dates.

[d] Brackets give State and are followed by counties sampled during the period indicated.

[e] The results for this period were for the most part not detectable. Some positive results were obtained, but represented barely detectable amounts of iodine-131 in the bovine thyroid. In general these positive results were 2–7 pCi/g thyroid and randomly scattered over the time periods and counties indicated.

[f] Numbers in parentheses represent number of samples collected from each county during the interval indicated. These may have been collected over several dates during the period or on only one date. (0) indicates county sampled but not during the given period.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations.[1] The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[2]

Summaries of environmental radioactivity data follow for the Bettis Atomic Power Laboratory, Feed Materials Production Center, Knolls Atomic Power Laboratory, and the S1C Prototype Reactor Facility.

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[1] Copies of these reports are available from the Division of Public Information, Atomic Energy Commission, Washington, D.C. 20545.

[2] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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1. Bettis Atomic Power Laboratory
July–December 1965[3]

Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pennsylvania. Routine environmental monitoring data from the sampling locations shown in figure 1 show no significant contribution from laboratory operations to environmental radioactivity levels.

Liquid radioactive waste

Liquid effluent discharged from the laboratory is sampled continuously. Composite samples are analyzed weekly for gross alpha and gross beta-gamma activity, and quarterly for strontium–90 activity.

The average concentration of gross beta radioactivity in the main laboratory liquid effluent during the second 6 months of 1965 was 650 pCi/liter. This was lower than the average concentration of 3,000 pCi/liter observed in the first half of 1965. The average concentration of strontium–90 for this period was 20 pCi/liter, which is lower than the concentration of 110 pCi/liter for the first 6 months of 1965. The gross radioactivity concentration in the critical facility effluent averaged 1,500 pCi/liter, which was higher than the average concentration of 920 pCi/liter for the first 6 months of 1965.

Background monitoring stations

Beta-gamma background radiation levels were continuously monitored and recorded at monitoring stations located at the periphery of the laboratory property. The use of background monitoring stations was terminated as of November 14, 1965, and 34 film badges were located on the peripheral fence at 100-yard intervals. These badges were collected on January 25, 1966, and the average background radiation levels were determined for the period from November 11, 1965, through January 25, 1966. In the future, badges will be collected and read quarterly or immediately following an accidental environmental release or radiation incident.

The results obtained from the beta-gamma background monitoring stations during the

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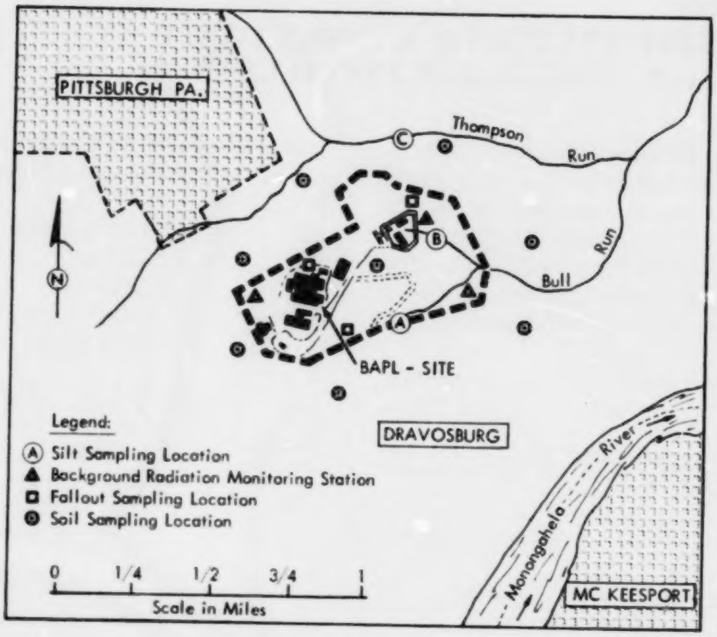
[3] Summarized from "Environmental Radioactivity at the Bettis Atomic Power Laboratory for the Second Six Months of 1965 and for Calendar Year 1965" (PNR-DEV-136).


PITTSBURGH PA.
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Ⓐ Silt Sampling Location
▲ Background Radiation Monitoring Station
□ Fallout Sampling Location
⊙ Soil Sampling Location
0
1/4
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3/4
1
Scale in Miles
Monongahela River
MC KEESPORT

Figure 1. Bettis Atomic Power Laboratory sampling stations

period July to November 14, 1965, are summarized in table 1.

There was an increase of 0.022 mR/hour in the mean beta-gamma background radiation level for the period July to November 14, 1965, as compared to the results for the first 6 months of 1965. This was due to the higher background levels at station 4, which were due to the close proximity of the station to a critical test facility.

Table 1. Beta-gamma radiation, background monitoring stations, July–November 14, 1965

Exposure levels (mR/hr)	Station		
	1	3	4
High weekly average	0.100	0.057	0.182
Low weekly average	0.012	0.010	0.032
Mean	0.018	0.014	0.061

The results obtained from the film badge monitors during the period from November 11, 1965, to January 25, 1966, are summarized in table 2.

Fallout

Fallout samples are collected at three locations at the perimeter of the laboratory. Samples are collected over a period of 1 month in high-wall, stainless-steel pots, and are analyzed for gross beta activity. The average monthly concentration of radioactive fallout for the second half of 1965 was 3.98 nCi/m². This value is essentially the same as the average monthly concentration of 3.86 nCi/m² for the first 6 months of 1965.

Table 2. Beta-gamma radiation, film badge monitors November 11, 1965–January 25, 1966

Area	Exposure levels, mR/hr	
Main laboratory area (20 locations)	Maximum Minimum Average	0.230 0.006 0.034
Critical facility area (14 locations)	Maximum Minimum Average	0.033 0.011 0.020
All locations	Average	0.028

Soil samples

Soil samples were collected at the eight locations shown in figure 1. These samples are not routinely analyzed. The collection of soil samples was discontinued in November 1965.

Stream silt

Stream silt samples were taken quarterly at the three locations shown in figure 1. The results of analysis of these samples are presented in table 3.

Table 3. Radioactivity in stream silt, July–December 1965

Period	Location	Silt concentrations (pCi/g)	
		Alpha	Beta-gamma
Third quarter, 1965	A	25	1,100
	B	20	22
	C	41	20
Average		29	380
Fourth quarter, 1965	A	30	180
	B	19	33
	C	25	26
Average		25	80
Second half, 1965 Average		27	230

The average alpha concentration in the stream silt samples was not significantly different from the concentration of 29 pCi/g for the first 6 months of 1965. However, the average beta-gamma concentration was higher than the concentration of 85 pCi/g for the first 6 months of 1965. This was the result of the higher concentration in the third quarter sample from location A, which was probably due to the higher beta-gamma concentrations in the main plant's liquid effluent being discharged near location A.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July 1962–June 1963	April 1964
July 1963–December 1963	November 1964
January–June 1964	April 1965
July–December 1964	October 1965
January–June 1965	April 1966

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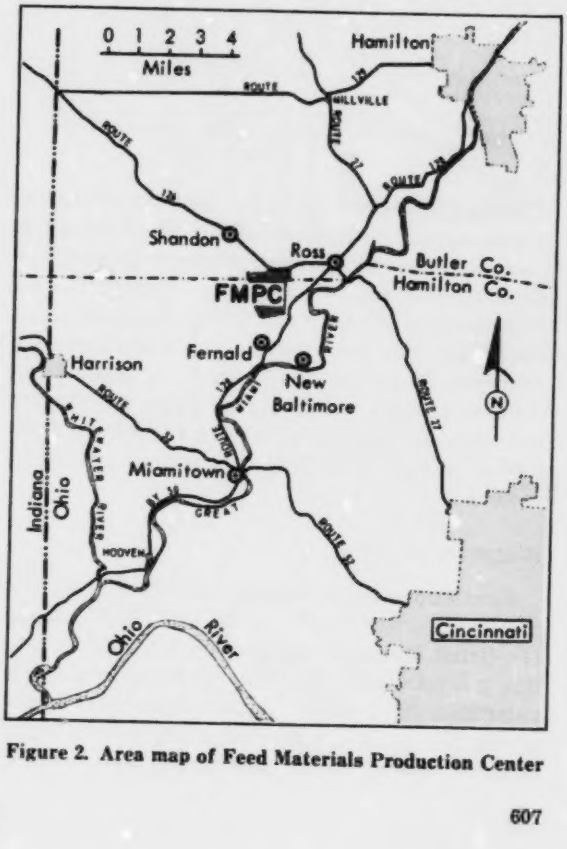
2. Feed Materials Production Center July–December 1965[4]

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 2. Cincinnati and Hamilton—the larger nearby communities—are situated 20 and 10 miles, respectively, from the center. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium, and with fabricating the metal into fuel elements.

An environmental survey program of air and water sampling is maintained to check the effectiveness of dust collectors and waste treatment processes. Inspection of the data indicates that releases of radioactive materials to the environment is controlled as required by AEC and State of Ohio regulations.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Miles
Hamilton
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Millville
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Route 129
Route 126
Shandon
Ross
FMPC
Butler Co.
Hamilton Co.
Fernald
New Baltimore
Harrison
Route 52
Whitewater River
Miami River
Route 128
Miamitown
Great Miami
Hooven
Indiana
Ohio
Ohio River
Cincinnati
N

Figure 2. Area map of Feed Materials Production Center

---

[4] Summarized from "Feed Materials Production Center Environmental Monitoring Semi-Annual Report for the Second Half of 1965" (NLCO-972).

Air monitoring

FMPC uses dust collectors such as bag collectors, electrostatic precipitators, and scrubbing towers which remove nearly all of the airborne particulates generated during the main plant operations. The environmental air sampling program provides an indication of the amount of material released into the atmosphere.

Onsite samples were taken at four permanent sampling stations located at the four corners of the production area shown in figure 3. Offsite samples were taken by a mobile unit operated at various distances and directions from the plant determined by local meteorological conditions on the day of sampling. Approximately 20 percent of all samples are taken upwind from the plant. The data for the offsite samples are averaged in groups according to distance from the production area. Concentrations of uranium and total activity of airborne particulates sampled at onsite and offsite locations are given in table 4.

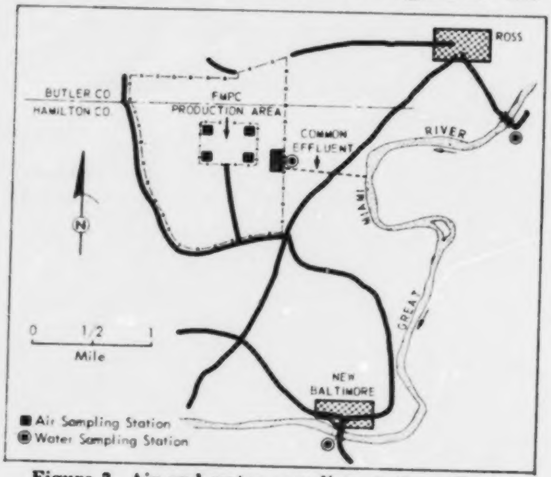

Figure 3. Air and water sampling stations, Feed Materials Production Center

Table 4. Radioactivity levels of airborne particulates July–December 1965

Location	Number of samples	Average concentrations, pCi/m³	
		Uranium	Total activity
Onsite:			
Southwest	27	<0.1	0.2
Northwest	27	<0.1	0.1
Northeast	27	0.1	0.3
Southeast	27	<0.1	0.2
All onsite samples	108	0.1	0.2
Offsite:			
0–2 miles from FMPC	20	<0.1	0.4
2–4 miles from FMPC	16	<0.1	0.1
4–8 miles from FMPC	19	0.1	0.2
8–12 miles from FMPC	12	<0.1	<0.1
All offsite samples	67	0.1	0.2
AEC Standard		2.0	100

Water monitoring

Continuous daily samples, collected from the combined sewer leading from the FMPC site to the Great Miami River, are analyzed for uranium and total activity. The combined sewage is composed of treated liquid effluent from the production plants, water treatment plants waste effluent, storm sewer discharge, and treated sanitary sewage. Using the data from the combined sewage samples and stream flow data for the Great Miami River, the FMPC contribution to radioactivity concentrations in the river may be calculated. To check the calculated results, weekly upstream and downstream spot samples are taken at the locations shown in figure 3. Table 5 presents the calculated and the spot check river concentrations. Since the calculated concentration represents only the contribution from FMPC, it should be compared with the difference between the upstream and downstream measurements.

Table 5. Concentrations of uranium and total activity in the Great Miami River, July–December 1965

Location	Method of determination	Number of samples	Average concentrations (pCi/liter)	
			Uranium [a]	Total activity [b]
Sewer outfall	Calculated from sewer concentrations and stream data (continuous sampling).	184	3	10
Upstream	Spot samples	30	5	50
Downstream	Spot samples	34	14	60
Difference			9	10
AEC Standard			20,000	3,000

[a] MPC, 20,000 pCi/liter
[b] MPC, 3,000 pCi/liter

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July 1961–June 1962	March 1963
July 1962–December 1963	May 1964
January–June 1964	April 1965
July–December 1964	October 1965
January–June 1965	April 1966

3. Knolls Atomic Power Laboratory July–December 1965[5]

General Electric Company
Schenectady, New York

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the Atomic Energy Commission in the development of atomic power for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site, located as shown in figure 4. The Knolls site occupies approximately 170 acres on which are located adminstrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops; decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards. The data that follow indicate that laboratory waste operations have complied with AEC requirements.

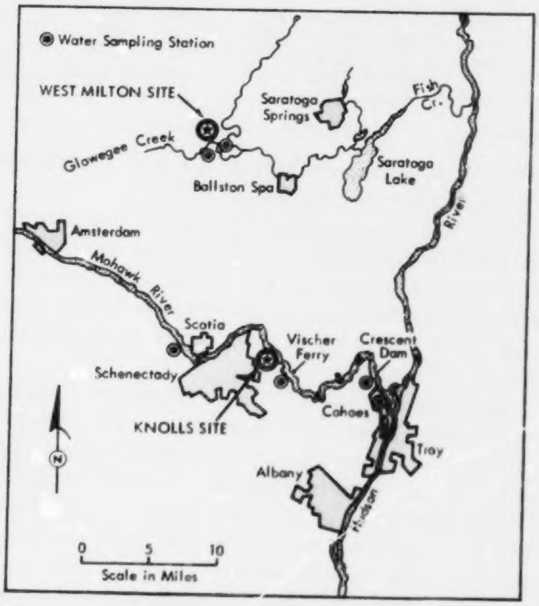

Figure 4. Environmental monitoring locations, KAPL

Air monitoring

Environmental airborne radioactivity is measured at two locations on the Knolls site, four locations at the West Milton site, and at the General Electric Company Research Laboratory approximately 1 mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. Each environmental monitoring station is equipped with film dosimeters to detect integrated gamma radioactivity levels. The average airborne beta-gamma radioactivity at each of the three areas for July–December 1965 was 0.09 pCi/m^3.

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the perimeter of KAPL at both the West Milton and Knolls sites. The perimeter survey of December 1965 showed normal background radiation levels for the geographic location. The results of this perimeter survey, extrapolated to an annual exposure, indicate average perimeter radiation levels of less than one-tenth roentgen per year.

Liquid waste monitoring

The dilution potential of the Mohawk River is utilized to a limited degree in the disposal of liquid radioactive wastes from the Knolls site. All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated through the monitoring of the concentration of fission products in the collection tanks and the control of the discharge rate of the effluent. A continuous proportional sample of the Knolls site combined sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of weekly composite samples show that strontium-90 is the principal component to be considered in control. The amounts and the radionuclide content of the combined sewer effluent discharged from the Knolls site have been summarized in table 6. A total of 329 millicuries of beta activity was discharged to the Mohawk River during the 6-month period at monthly average concentrations ranging from 270 to 720 pCi/liter.

---

[5] Summarized from "Knolls Atomic Power Laboratory Semiannual Environmental Monitoring Report, July–December 1965" (Volume 7, Number 2).

Table 6. Radionuclide concentrations in the Knolls site waste effluent, July–December 1965

Radionuclides	Concentration (pCi/liter)	AEC standard (pCi/liter)
Strontium-89	<4.2	3,000
Strontium-90	160	300
Yttrium-90	100	2,000
Ruthenium-106	<4.2	10,000
Iodine-131	<4.2	300
Cesium-137	110	20,000
Cerium-praseodymium-144	30	10,000

Since Glowegee Creek does not have a reliable dilution potential, the radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release to the creek. A total of 3.02 millicuries was discharged at two points into Glowegee Creek during the six-month period at monthly average concentrations ranging from 6 to 77 pCi/liter. Samples of the Glowegee Creek water are taken once a week at two locations, one at about 150 feet above the point where the S3G effluent enters the stream, and the other 2,640 feet below the S3G discharge or 1,500 feet below the D1G discharge.

Mohawk River water is sampled continuously at the point of disharge from the Knolls site; at the General Electric Company powerhouse eight miles upstream from the site; at the Vischer Ferry powerhouse approximately two miles downstream; and at the City of Cohoes pumping station about 13 miles downstream. Results are given in table 7.

Table 7. Gross beta-gamma activity in streams receiving effluents, July–December 1965

Streams and sampling locations	Concentration (pCi/liter)	AEC standard (pCi/liter)
Mohawk River (Knolls site)		100
G.E. powerhouse (upstream)	8	
Vischer Ferry (downstream)	7	
Cohoes (downstream) raw water	8	
Cohoes (downstream finished drinking water	5	
Glowegee Creek (West Milton site)	----------	3,000
Upstream	4	
Downstream	7	

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July 1961–June 1962	July 1963
July 1962–December 1963	June 1964
January–June 1964	April 1965
July–December 1964	October 1965
January–June 1965	April 1966

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4. S1C Prototype Reactor Facility July–December 1965[c]

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype is a land-based nuclear submarine power plant operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. The prototype contains a pressurized water reactor power plant which is used to conduct research and development work and to train personnel in the operation of naval reactor power plants.

Reactor power operations at the S1C prototype facility began in December 1959.

The low level radioactive waste discharged intermittently from S1C Prototype operations consists mainly of water. Small quantities of airborne particulates in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially, all of the radioactive waste originates from the activation of minute amounts of impurities in corrosion products in the circulating water used as a reactor coolant. Small quantities of gaseous waste result from the activation of minute amounts of air dissolved in the coolant water.

All materials released to the environment are routinely monitored to assure that waste dis-

---

[c] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring Report, July 1 to December 31, 1965" (CENRD-3163-RS-531).

Table 9. Radioactivity in liquid wastes discharged into the Farmington River, S1C, July–December 1965

Activity	Quantity
Total beta activity (millicuries)	21.9
Average concentrations (pCi/liter):	
Gross beta	5,800
Cobalt-60	4,200
Iron-59	810
Manganese-54, cobalt-58	1,500

less than the detectable level of 10 pCi gross beta/liter. All seven mud samples contained less than the detectable level of 10 pCi gross beta/gram.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1961	March 1962
July 1961–June 1962	July 1963
July 1962–December 1963	June 1964
January–June 1964	April 1965
July–December 1964	October 1965
January–June 1965	April 1966

Section V. Technical Notes

REPORTED NUCLEAR DONATIONS, SEPTEMBER 1966

During September 1966, three U.S. nuclear tests, all conducted underground at the Nevada Test Site, were announced by the U.S. Atomic Energy Commission.

A test of low yield (less than 20 kilotons TNT equivalent) was conducted on September 12; a test of low-intermediate yield (20 to 200 kilotons TNT equivalent) was conducted on September 23; and a test of low yield was conducted on September 29.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

DIGEST OF HEALTH STANDARDS AND STATE REGULATIONS FOR RADIOACTIVITY IN WATER. *J. L. S. Hickey. Radiological Health Data and Reports, Vol. 7, October 1966, pp. 549–554.*

Numerical limits of seven published standards and guides for radium-226, strontium-90, and unidentified radionuclides in water for various applications and population groups are summarized. Of the 54 States and Territories, 47 have legislation or regulations for control of radionuclides in water. Of these, 31 have adopted some form of numerical limits for control of radionuclides in water. Sixteen States and Territories have general legislation permitting control of radiation exposure but no numerical limits for radionuclides in water, and seven have no specific legislation for control of radionuclides in water.

KEY WORDS: Atomic Energy Commission, Council of State Governments, Federal Radiation Council, International Commission on Radiological Protection, National Committee on Radiation Protection, Public Health Service Standards, radium-226, strontium-90, water, World Health Organization.

PRECISION AND SENSITIVITY OF GAMMA SPECTROMETRIC MEASUREMENTS IN MILK. *M. A. Wall* and *A. S. Goldin. Radiological Health Data and Reports, Vol. 7, October 1966, pp. 555–559.*

The performance of a gamma spectrometric laboratory comprised of four closely similar detector-analyzer systems was evaluated by examining the results obtained on environmental fluid milk samples. The sensitivity of the system was evaluated by measurements of iodine-131 concentrations, mostly at the zero counting level. The precision of the system was measured on the basis of replicate determinations of potassium and cesium-137 at higher counting levels.

At low and intermediate levels, variability was not significantly different from that calculated from radioactivity statistics. Only at the highest level encountered was there any indication of a greater variability than would be expected from these statistics, and even at this level the difference was not significant at the 95-percent confidence level.

KEY WORDS: barium-140, cesium-137, counting error, gamma spectrometry, iodine-131, milk, Poisson distribution, precision, sensitivity.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 11, November 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

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Department of Health, Education, and Welfare
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Reports

NUCLEAR POWER PRODUCTION AND ESTIMATED KRYPTON-85 LEVELS

J. R. Coleman and R. Liberace[1]

Worldwide environmental levels of krypton-85 are projected to the year 2060, based on published estimates of population increase and prediction of world power needs. Factors considered include estimates of the growth of nuclear reactor power as a fraction of total power production based on population growth and per capita power consumption, the "mix" of the reactor economy (thermal, thermal converter, and fast breeder systems), and the decay rate of krypton-85 inventory. Krypton-85 buildup is discussed in relation to population dose and also to the possible effect of krypton-85 contamination on the uses of noble gases.

In 1962, the National Academy of Sciences, National Research Council (*1*), stated that if worldwide industrial collapse due to the exhaustion of fossil fuels and high-grade ores of metals within the next few centuries is to be forestalled, newer and larger sources of energy suitable to the requirements of large-scale industrial operations will be required.

With limited amounts of fossil fuels, with solar power an uncertain factor, and water power inadequate, nuclear energy alone appears of sufficient magnitude and adaptability to meet the world's future energy requirements. Thus, the orderly development of nuclear fuels as a primary source of worldwide energy must be considered a necessity. We must, however, remain continually aware of the environmental consequences of this rapidly expanding industry—the potential long-term buildup of radioactive waste materials in man's environment.

Because of the difficulty of their economical removal during fuel reprocessing noble gases are of special interest. The removal of such gases at the present time involves costly techniques which are reasonable only if very small volumes or flow rates are used. From the standpoint of long-term buildup, only krypton-85 with a half-life of approximately 10 years is of importance. Although the hazard associated with krypton-85 is not great, it was pointed out as early as 1959 that its long-term buildup in the environment would necessitate developing methods for removing it from power reactor fuel reprocessing off gases (*2,3*).

Already, minor nonhealth-related indications of the possible future problems of environmental krypton contamination have been observed. Ostrowski and Jelen (*4*) reported that the krypton-85 contamination present in commercial krypton as early as 1963 was a serious obstacle in the use of ionization detectors filled with this gas. Lasseart and Kellershohn (*5*) reported that krypton-85 contamination of xenon was mainly responsible for the background in a self-triggering spark chamber used in nuclear medicine.

---

[1] Mr. Coleman at the time of writing this article was chief of the Models and Predictions Staff Studies, Radiation Surveillance Center, and Mr. Liberace is a nuclear engineer associated with the Nuclear Facilities Environmental Analysis Section, Technical Operations Branch, both of the Division of Radiological Health, Public Health Service, Rockville, Maryland 20852.

Because of these implications and the possible radiation exposure to the population that might result from the long-term buildup of krypton-85, it is important that projections of the future environmental contamination be made. This paper presents an estimate of the magnitude of the levels of krypton-85 in air and the dose that would result from the long-term buildup in the earth's atmosphere over the next 100 years.

The method of approach was first to project world power needs to the year 2060 and then estimate the fraction of these needs that might be met by nuclear fuels. Once the total world nuclear power was estimated, a mixed reactor economy made up of thermal, thermal converter, and fast breeder systems was used to calculate the resulting krypton-85 production and its buildup in the earth's atmosphere as a function of time.

World nuclear energy usage

The major source of krypton-85 is expected to be the fission product gases released from plants processing spent nuclear fuel elements. In general, only a relatively small quantity would be released from actual reactor operations (*6,7*) and nuclear explosions (*8–10*).

For the purpose of this discussion it was assumed that the future production of krypton and the associated atmospheric contamination will closely follow the demands for nuclear electric power, nuclear ships, and other potential large users of nuclear energy. Although nuclear power growth projections for the United States have been made through the year 2000, and generalized projections to the year 2060 (*11*), any prediction of future krypton-85 levels in the earth's atmosphere must be based on estimates of the growth of the total nuclear industry throughout the world.

The method of estimating future nuclear power was based on an estimate of the total world input power requirements up to the year 2060 and a judgment as to the portion of this power that might conceivably be nuclear. Total world input energy was estimated by two methods. One was essentially the method used by Putnam (*12*) and the other utilized the data of Felix (*13*). To project world energy requirements by either of these methods requires a projection of both world population and annual per capita energy consumption.

The expression used for projecting world input energy requirements by the method of Putnam is shown in equation (1).

$$WE = \underbrace{N_o\,(1+\delta N_o)^\tau}_{\text{Population projection}}\;\underbrace{R_o(1+\delta R_o)^\tau\,\frac{1}{\epsilon(\tau)}}_{\text{Input energy projection}} \qquad (1)$$

where WE = net world annual input energy requirements, BTU,

N_o = 1947 world population,

δN_o = annual fractional increase in world population,

R_o = 1947 world average annual output energy requirement, BTU/person,

δR_o = annual fractional increase in world output energy requirement,

$\epsilon(\tau)$ = weighted average efficiency of input energy use,

and τ = time in years and using 1947 as a base.

Estimates of the world input energy were made on the basis of three population projections to 2050, one leading to a projected population of approximately 6 billion, another to a projected population of approximately 8 billion, and the third to a projected population of approximately 14 billion. The first two of these projected populations were selected to be consistent with the range of maximum plausible populations suggested by Putnam (*12*). The third value was selected to be in agreement with more recent population estimates made for the year 2000 by Cook (*14*). Cook estimated a world population of 5 to 7 billion by the year 2000, with a median value of approximately 6 billion. The third population estimate used in this investigation was based on an extrapolation of Cook's median projection to the year 2060.

Consistent with Putnam, the 1947 average per capita annual input energy requirement in equation (1) was taken as 3.98 x 10^7 BTU/capita•year (8.8 x 10^6 BTU/capita•year output), and the annual fractional increase in world output energy requirements (δR_o) as 0.03. Although the rate of growth of world output energy demand is not constant and may be lower than 0.03, this value was selected by Putnam as a plausible contingency that must be considered. The weighted average efficiency [$\epsilon(\tau)$], defining the relationship between usable energy (electric power) and thermal energy, was taken to be 0.22 in 1947, with a linear increase to 0.36 in 1980, and a constant value of 0.36 from 1981 to 2060. As a result of increased industrialization, this changing efficiency was selected to reasonably represent the projected trend in weighted average efficiency for world energy use through the year 2060. The results of these calculations of world input energy demand are shown as curves 1, 2, and 3 in figure 1.

In calculating the world input energy requirements, utilizing the data of Felix, a changing growth rate for per capita input energy demand was used. That is, as the level of industrialization increases, the per capita consumption of energy increases but at a continuously slower rate. Thus, the calculations involve estimating the annual fractional increase in per capita consumption of energy as a function of the changing per capita consumption itself. The values used ranged from 0.036 in 1961 to approximately 0.010 in 2055. Annual per capita input energy requirements ranged from 4.06 x 10^7 BTU/capita•year in 1961 to 29.2 x 10^7 BTU/capita•year in 2060.

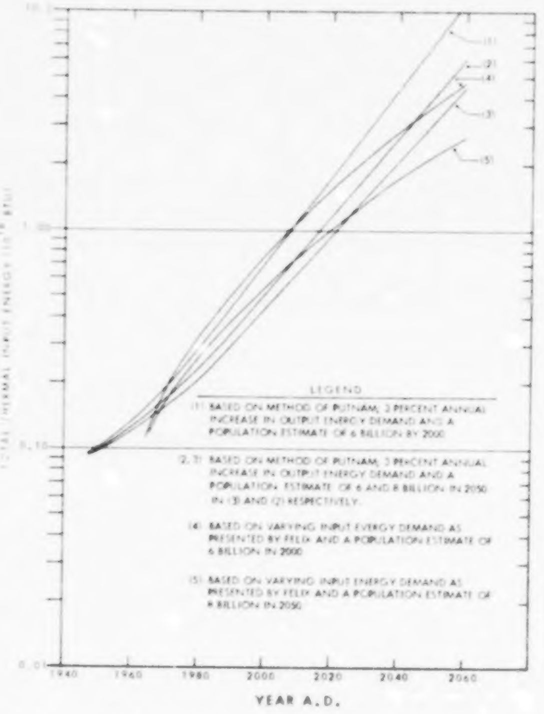

Figure 1. Estimated world input energy demand 1947–2060

Total world input energy requirements were then estimated by multiplying the estimated world per capita demand by the projected world population. Two population projections were used: the eight-billion estimate for the year 2050, and the median estimate based on Cook. The results of these calculations are shown as curves 4 and 5 in figure 1. In the remainder of this presentation, curve 2 in figure 1 will be used to represent a reasonable balance of the estimates of world energy, while the other curves will be used to represent the upper and lower range of values that might exist.

The fraction of the total world energy requirements supplied by nuclear power was estimated for the most part from consideration of the U.S. AEC Report to the President—1962 (*11*).[2] It was assumed that the world nuclear input energy might reasonably parallel the projections for the United States after the year 2000. Thus, projections were first made for the period from 2000 to 2060, assuming that the fraction of the world total input energy supplied by nuclear power would be approximately the same as that projected for the United States. Consistent with the report to the President, it was assumed that approximately 20 percent of the total input energy requirements (somewhat less than 50 percent of the electrical energy) might be satisfied by nuclear fuels in the year 2000. This fraction would increase to nearly 50 percent by the year 2060, at which time essentially all of the electrical energy would be supplied by nuclear power. The data of Felix would yield a somewhat lower estimate of the proportion of total energy supplied by electricity. However, the estimates from the AEC's report to the President were selected as representing a reasonable projection of future demands.

---

[2] These predictions have already been exceeded by a factor of three for the past 3½ years.

For the period prior to the year 2000, it was assumed that the ratio of world nuclear energy to the United States nuclear energy would remain essentially constant. This ratio, based on the projected world nuclear energy demand (curve 2, figure 1) and the U.S. projection for the year 2000 (*11*), was found to be 2.82, a quite reasonable value in that the total world energy usage has been roughly three times that of the United States for approximately 100 years (*12*). The projected U.S. nuclear energy prior to the year 2000 was obtained from the report to the President.

The resultant curve for estimated world nuclear energy is shown in figure 2. As previously mentioned, curve 2 in figure 1 was used as the most reasonable balance between the upper and lower estimates. The upper and lower estimates are based on the extremes in the world energy projections from figure 1. It should be pointed out that the lower end of the curve is far more uncertain than it appears in the figure, due to the method of estimation.

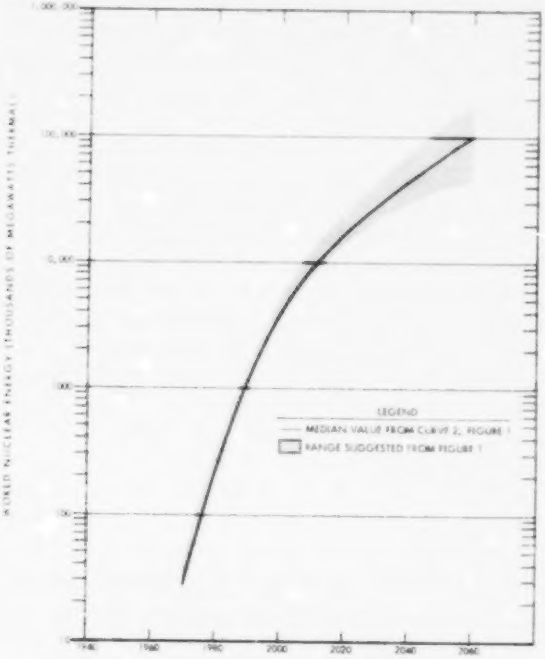

Figure 2. Estimated world nuclear energy (thermal), 1970–2060

Krypton–85 production, atmospheric concentration, and annual dose

For the purpose of calculating krypton–85 production, a mixed reactor system was assumed, since the fission yield of krypton–85 depends on the nuclear fuel used and the neutron energy. Three types of reactors were considered as comprising the mixed system:

1. Thermal (uranium–235)
2. Thermal converters (uranium–233, thorium–232)
3. Fast breeders (plutonium–239, uranium–238)

It was assumed that up until 1980, the total reactor complex would be made up of thermal systems utilizing uranium–235. In approximately 1980, thermal converters would come into use and shortly thereafter fast breeders would be introduced. The split in supplied power in the year 2000 was taken to be 7 percent, 33 percent, and 60 percent for thermal, thermal converters, and fast breeders, respectively (*15*). By the year 2020, the system would consist of approximately 20 percent thermal converters and 80 percent fast breeders, the suggested ratio of dynamic equilibrium (*15*).

The general equation used to estimate krypton–85 production is shown in equation (2).

$$C = 8.4 \times 10^5 P_i Y_i (1 - e^{-\lambda\tau}) e^{-\lambda t} \qquad (2)$$

where C = curies of krypton-85,
P_i = total nuclear power supplied by reactor system i, Mw
Y_i = fission yield of krypton-85 for reactor system i,
Y_i (uranium-235, thermal) = 0.00293 (*16*),
Y_i (uranium-233, thermal) = 0.0058 (*16*),
Y_i (plutonium-239, fast) = 0.00076 (*17*),
λ = decay constant for krypton-85 (1.84×10^{-4} days $^{-1}$),
τ = irradiation time (365 days),
and t = cooling time (150 days).

With the system defined, the annual krypton-85 production was calculated. The atmospheric concentration was then estimated by diluting the annual production into the total atmosphere and decaying the previous reservoir of krypton-85 by 1 year. The total atmosphere was taken to be 5.14×10^{21} grams (*18*). The results of these calculations are shown graphically in figure 3, and as before are presented as a median and a range. A second upper range is also presented, based on the consideration of 75 percent of the krypton-85 being released into the Northern Hemisphere and little interchange across the Equator. The 75 percent to 25 percent weighting is a rough estimate of the hemispheric population distribution beyond the year 2000. The concentrations are given in pCi/g of air, which corresponds roughly to 1,000 pCi/m^3 of air. Also shown in figure 3 are a number of measured values of krypton-85 in air (*10*) for comparison. In figure 4, the concentrations have been converted to dose by use of the relationships in the National Bureau of Standards Handbook 69 (*19*).

Discussion

Although the primary interest of this presentation is directed at the environmental buildup resulting from the long-term release of krypton-85 into the atmosphere, some discussion regarding the population and energy projections is warranted. Any projection of dynamic variables such as population or energy demand for periods as long as 100 years is fraught with uncertainties and it is difficult to reasonably assign probability or error to the values obtained. The projection must be based on past information; and inherent in this is the assumption that no dramatic changes in growth rates as related to past experiences will take place. In essence, Cook has stated that barring nuclear war, massive famine, worldwide catastrophe, or some miraculous form of fertility control, the 7-billion total population predicted by the year 2000 seems likely (*14*). However, such population growth depends greatly on the ability of the world economy to support these large populations.

Unless most of the inefficient farm cultures of underdeveloped nations transform to more efficient patterns of farming, populations of the magnitude projected would appear implausible (*12,14*). It is inevitable, therefore, that large populations must also be characterized by higher industrialization and relatively high demands for per capita energy consumption. The economy projected for the world in the year 2060 would be very nearly the level of industrialization of the United States today. The projections are based on past information and on estimations relating industrialization, energy use, and estimated population growth. In as far as the data from past experience can characterize future trends, the projections of world input energy demands are believed reasonable.

Throughout the presentation, several projections of world energy demands have been used in order to present a range of levels of krypton-85 that might be reasonably expected. On the basis of present knowledge, it would be difficult

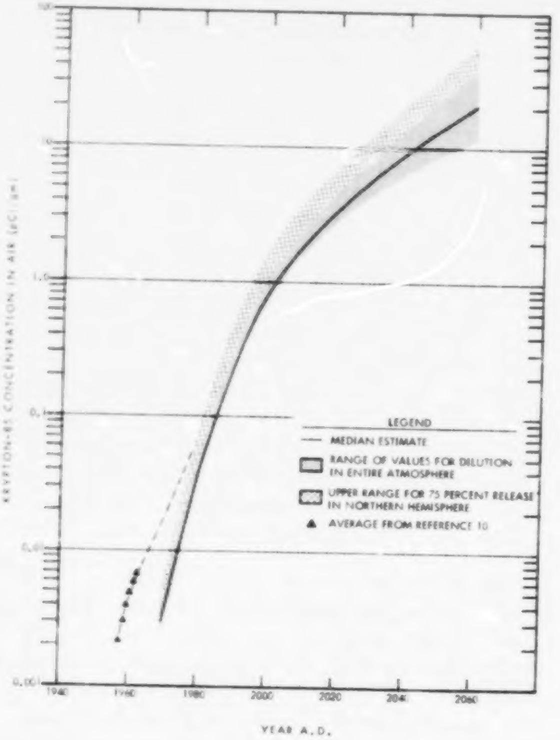

Figure 3. Estimated krypton-85 concentration in air 1970-2060

to visualize levels of krypton–85 differing from the projected median estimate after the year 2000 by more than an order of magnitude in the upward direction. Measures to reduce krypton–85 levels, including extraction at the source or replacement of fission power by fusion power, might make a greater change downward. At present the predicted values shown on the curves of figure 3 are not in agreement with the measured values of krypton–85 indicated by the single data points. This difference is due to inadequate knowledge of krypton–85 releases from fuel plants presently processing plutonium and other fissionable materials both in the United States and in other countries of the world. Since the quantity of fuel reprocessed by these government plants and by commercial plants cannot be estimated in the next few years, and because of the initial uncertainty in the delay between time when the fuel leaves the reactor core and the time when it is processed in a commercial fuel reprocessing facility, the portion of the curves between 1965 and 1980 will not accurately predict the levels of krypton–85 in the environment.

The future buildup of krypton–85 and the associated whole-body dose is characterized in figures 3 and 4. Although krypton–85 is not considered a significant health hazard at the present levels, by the year 2060 the resultant dose is estimated to be of the order of 50 millirads per year and may be as high as 100 millirads per year. From a public health standpoint, a dose of 50 millirads per year to the total population from krypton–85 is acceptable if other sources of exposure are adequately controlled. This is several times the annual whole-body dose associated with fallout from past weapons testing, and approaches the guideline limits for radiation exposure of general population groups, *i.e.* 170 mrad per year.

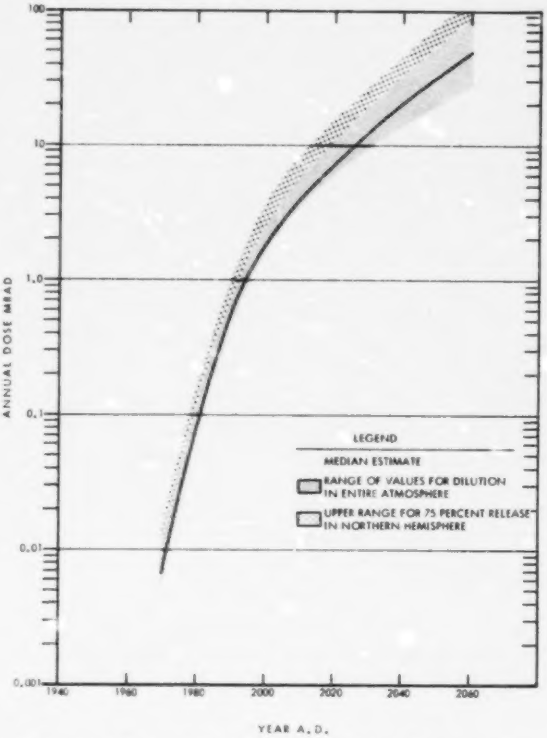

Figure 4. Estimated annual dose from krypton–85 1970–2060

Also of importance is the possible effect of krypton–85 contamination on the uses of noble gases. From figure 3 it is estimated that the levels of krypton–85 contamination of the noble gases observed in 1963 (*10*) may be increased by roughly an order of magnitude by 1980; two orders of magnitude by 1990; and roughly three orders of magnitude by 2010. Table 1 presents the approximate specific activities for atmospheric krypton and total noble gases as calculated from the projection of figure 3.

In considering table 1, the question arises as to what limitations these levels might impose on the production and use of commercial noble gases, aside from possible future health considerations.

Our predictions indicate that krypton–85 remains as a potential future source of environmental contamination requiring evaluation by those concerned with the balancing of risks and benefits of nuclear energy.

Table 1. Activity due to krypton-85 in atmospheric noble gases

Gas	Estimated 1963 activity (dpm/g)	Projected future activity dpm/g noble gas				
		1980	2000	2020	2040	2060
Krypton-85	5.0×10^3	2.3×10^4	4.5×10^5	2.0×10^6	4.5×10^6	1.0×10^7
All other noble gases	2	9	180	800	1,800	4,000

Acknowledgment

The authors wish to express their thanks to Mr. Richard Grundy[3] for the computer programming and systems analysis associated with this investigation.

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FILM BADGE SERVICE PERFORMANCE[1]

D. E. Barber[2]

Approximately 2,000 film badges were irradiated with various types and energies of radiation to provide measures of film badge service accuracy upon which provisional performance control limits could be based. Exposures ranged from 2 milliroentgens to 497 roentgens. Film badge services 1) helped design the test procedures, 2) submitted badges for exposure, 3) reported exposure interpretations, and 4) assisted in determining provisional performance control limits. A measure of accuracy called an *error factor* was determined for each service for each type and energy of radiation in the test. These error factors are tabulated to show the accuracy of the film badge services tested. Frequency distributions of the error factors served as the basis for selection of provisional control limits to be used to define acceptable performance.

Reported here are the results of the most extensive test ever undertaken of the performance of film badge services. The test was conducted in 1965 by the National Sanitation Foundation (the Foundation) and included examination of commercial and federal film badge services. The work was done in response to a general concern about the accuracy with which film badge services report radiation exposures.

Procedures

Twenty-five different organizations (one company submitted two sets of film) each submitted 80 badges to the Foundation for irradiation with the various types, energies, and doses of radiation shown in table 1. Twelve of the 25 organizations were commercial film badge companies. After irradiations were completed by the Foundation, badges were returned to their suppliers for exposure evaluation. All services were informed of the test procedures to be used prior to the test. However, services had no prior knowledge of which badges were exposed to what type, energy, or dose of radiation.

Irradiation techniques used in the test have been described in detail in other reports (*1,2*).

Results

Log-log coordinate graphs of reported (y) versus delivered (x) irradiations were prepared for each film badge service and each type and energy of radiation used in the test. Figure 1 is an example of such a graph.

An "error factor" was then determined as follows: first, the reported irradiation geometrically farthest from the line, $y=x$, was noted and omitted from further consideration. (See discussion). The point that lay next farthest from the line, $y=x$, was then designated the "error factor point."

The "error factor," Y_e/X_e, was determined from the coordinates of the error factor point. This factor was used as the measure of accuracy of a service for each type and energy of radiation used in the test. Note that the error factor may be greater than 1.0, or less than 1.0 (as in figure 1). The upper error band has the equation $X=(X_e/Y_e)\ Y$, and the lower error band the equation $X=(Y_e/X_e)\ Y$. Although the error bands are geometrically equidistant from the perfect performance line, they do not

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[1] The work upon which this article is based was supported by the U.S. Public Health Service Contract No. PH 86-63-198 with the National Sanitation Foundation, School of Public Health, Ann Arbor, Michigan.

[2] At the time of this study, Dr. Barber was assistant professor, Department of Environmental Health, University of Michigan; he is now associate professor in the Environmental Health Department, School of Public Health, Mayo Hospital, University of Minnesota, Minneapolis.

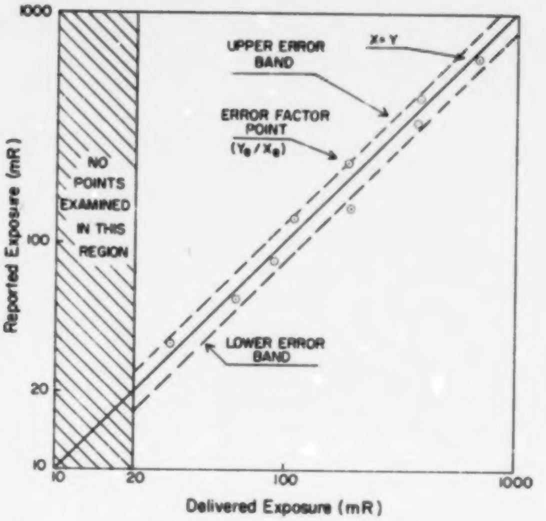

Figure 1. Example data showing a method of selecting the reported exposure used to determine the error factor

represent the same percentage error. To illustrate: an error factor of either 0.5 or 2.0 means that all but one of the points fall within minus 50 percent and plus 100 percent of the delivered exposures.

Error factors were computed separately for the gamma and beta components of mixed beta and gamma irradiations.

The error factors for the different organizations for each of the various types and energies of radiation in the test are shown in table 2. These data represent a measure of the present performance level of film badge services, and serve as the basis for the provisional performance criteria given in table 3. The control limits in table 3 were determined as follows:

1. The pooled frequency distribution (figure 2) of all the error factors in table 2 was examined. The error factors 0.20 and 1.80 were selected arbitrarily from figure 2 to be reasonable values for control limits for the film badge service industry as a whole. These error factors were chosen to encompass approximately 80 percent of all the error factors in figure 2.

2. The frequency distributions of the error factors for each type and energy of radiation in table 2 were then examined individually and qualitatively compared with the pooled distribution. If an individual distribution was broader than the pooled distribution, the control limits, chosen from the pooled distribution,

Table 1. Film badge irradiations per film badge service [a]

Group	Radiation	Added filter (mm)	kVp or source	1st HVL [b] 2nd HVL (mm)	Effective energy [c] (keV)	Irradiation range	Total number of film badges	Number of film badges receiving >20 mrem [d]
1	X-ray	1 Al	68	1.05 Al 2.00	23	6–288 mR	9	6
2	X-ray	1 Cu+1 Al	200	1.35 Cu 2.35	90	3–186 mR	9	6
3	X-ray	1 Sn+1 Cu+Th II [e]	270	4.10 Cu 5.60	175	9–287 mR	9	8
4	X-ray	1 Sn+1 Cu+Th II [e]	270	4.10 Cu 5.60	175	2–497 R	4	4
5	Gamma	Capsule only [f]	^{137}Cs	—	662	11–305 mR	9	8
6	Beta	Capsule only [g]	^{90}Sr-Y	—	—	23–276 mrad [i]	9	9
7	Beta+ gamma	Capsule only [g] Capsule only [f]	^{90}Sr-Y + ^{137}Cs	—	662	28–136 mR	9	9
8	X-ray+ gamma	1 Al Capsule only [f]	68 ^{137}Cs	1.05 Al —	23 662	17–390 mR	9	8
9	Fast neutrons	Capsule only [h]	Pu-Be	—	—	17–228 mrem	9	8
10	None	Two controls for neutron film badges+ two controls for all others				None	4	0

[a] Relative humidity during irradiations varied from 14 percent to 43 percent. Temperature varied from 23° to 27° C.
[b] Half-value-layer.
[c] Based on first HVL.
[d] The decision to eliminate from the test all doses less than 20 mrem was made after all irradiations had been completed.
[e] Th II = 0.4 mm Sn + 0.25 mm Cu + 1.0 mm Al.
[f] The ^{137}Cs source is encapsulated in 30 mils 303 S.S. + 30 mils 321 S.S.
[g] The ^{90}Sr-Y source has a 21 mg/cm^2 aluminum end window.
[h] The neutron source is encapsulated in 100 mils of tantalum + 30 mils of 304 S.S.
[i] Measured in air.

Table 2. Error factors (encompassing all but one of the data points) for irradiations greater than 20 mrem

	Radiation										
Service code	23 keV X	90 keV X	175 keV X low exposure	175 keV X high exposure	Beta	Gamma	β of $(\beta+\gamma)$	γ of $(\beta+\gamma)$	X+γ	Fast neutrons	Total asterisks
1	0.80	*2.66	0.84	*0.50	*3.64	*0.22	*0.01	*0.04	*0.49	—	7
2	*2.29	0.87	0.76	0.85	1.34	*0.69	1.58	*1.43	1.79	*0.04	4
3	1.14	1.02	0.90	0.66	1.43	0.81	1.30	0.80	0.85	0.76	0
4	*2.18	0.71	*0.12	*0.44	*1.52	*0.59	1.56	*0.65	1.36	2.00	6
5	0.79	*0.41	0.76	*>0.61	*1.74	1.31	*0.01	*0.43	*0.44	*0.02	7
7	*0.22	0.83	*0.53	0.83	*2.50	0.82	*3.35	0.89	*0.52	1.26	5
8	0.87	0.62	1.59	*1.68	1.30	*0.59	1.37	0.89	0.59	0.67	2
9	*3.00	0.61	*0.46	*0.36	1.41	0.77	*0.02	*0.64	*0.44	*6.70	7
9b	*0.54	0.61	*0.42	*0.02	*0.06	0.85	*0.01	*0.65	—	*[illegible].42	7
11	1.13	1.03	0.83	1.05	1.09	0.82	0.85	0.72	1.10	1.59	0
12	0.[illegible]4	*0.46	*0.50	0.63	1.41	0.80	1.77	0.82	0.83	0.80	2
13	0.7[illegible]	0.64	*0.53	0.67	1.28	0.76	*0.01	*0.86	0.73	0.72	3
14	0.7[illegible]	1.61	1.30	*0.52	1.29	0.88	1.46	1.12	*0.49	1.30	2
15	1.05	*0.57	0.77	1.09	*0.10	0.78	0.87	0.89	0.46	*0.23	3
16	1.50	0.88	0.68	1.15	0.93	1.22	0.61	1.29	0.68	*3.14	1
16b	1.37	0.92	0.75	0.91	1.22	1.19	0.81	*1.45	—	—	1
17	0.75	0.71	*0.45	0.67	1.08	0.78	1.30	0.73	—	1.31	1
18	*0.31	*0.24	*0.23	*0.07	*0.13	*0.33	—	—	*0.22	—	7
19	0.80	0.60	*0.54	0.70	*2.2[illegible]	0.82	*2.45	*0.29	0.63	1.92	4
21	*2.04	*2.82	*2.16	0.7[illegible]	*2.0[illegible]	*2.55	0.64	1.19	*2.90	*0.01	7
22	*0.42	1.5[illegible]	0.64	*>26.3	*0.45	*0.33	*0.02	*1.78	*0.24	*0.01	8
23	1.09	*3.94	1.25	*>1.20	*0.04	1.29	1.90	1.10	*0.52	*0.43	5
23b	*0.11	0.79	1.08	1.40	*0.05	1.27	0.96	1.10	*0.48	*0.34	4
24	1.27	0.68	1.58	*2.10	0.86	0.85	0.81	1.37	0.58	0.68	1
25	*2.09	1.67	*0.42	*>1.82	0.69	*0.01	*0.02	*1.85	*2.27	*2.57	8
26	0.90	*0.48	*0.54	0.80	0.87	0.87	1.22	0.86	—	0.59	2
Total asterisks	10	8	12	12	12	8	9	11	11	11	104

Notes:
Asterisks mean the error factor falls outside proposed control limits in table 3.
Dashes mean the service either did not provide reports for the indicated radiation or was not tested for the indicated radiation.
A "b" after the service code identifies film badges obtained through State health departments. Film badge services were not advised of the use of these badges.

were expanded and adopted for the radiation appropriate to the individual distribution. Similarly, if the individual distribution appeared narrower than the pooled distribution, the control limits applicable to the particular radiation in question were narrowed.

After the control limits were adjusted, it was observed that greater than one-half of the services fell within the control limits in table 3 for the individual types and energies of radiation in table 2. About two-thirds of the services demonstrated error factors which fell within the control limits for five or more radiation categories.

Discussion

This work involved the examination of film badge service performance for a number of radiation types, radiation energies, and irradiation ranges selected so that the majority of exposure conditions encountered in personal dosimetry were included. The data show that there is a rather broad gap between the better group and poorer group of services. The control limits would have to be expanded almost to the range of the error factors in table 2 to change appreciably the number of services in table 2 which demonstrated error factors within all the control limits in table 3.

It is not surprising that only two services demonstrated error factors which lay within all the control limits, because:

1. The individual frequency distribution for each type or energy of radiation in table 2 involved at most 26 error factors. This is a small number of observations for plotting frequency distributions. Where the observations were widely distributed, it was not clear what control limits should be chosen for the particular radiation in question.
2. Services demonstrated error factors over a broad range from one type of radiation to another.

An arbitrary degree of freedom was introduced into the test by ignoring the reported irradiation farthest from the line y=x, figure 1. This was done to reduce the likelihood of a service failing a subsequent test on a purely statistical basis. If the point farthest from the line y=x had been used as the basis for control limits, all reported irradiations in a category would be involved in tests against the control

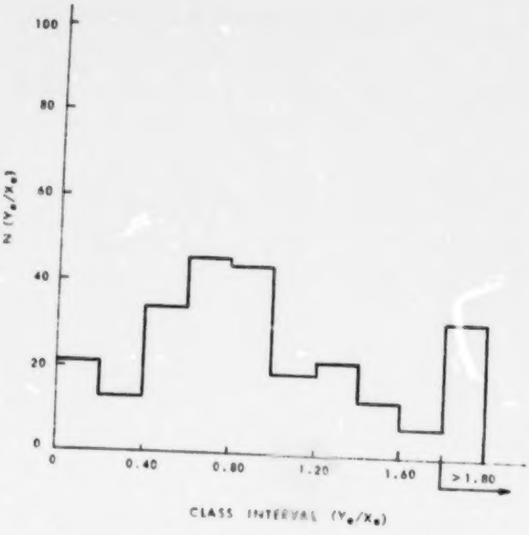

Figure 2. Pooled distribution of Y_e/X_e

limits, and chance would play a stronger role in the failure of services to meet the control limits in subsequent tests. On the other hand, had the point closest to the line y=x been used, only one out of nine reported irradiations in a category (1 out of 4 for the high exposure x-ray group) would be involved in tests against the control limits, and the likelihood of success in future tests for purely statistical reasons would be high. More tests will have to be made before the probability of successes in repeated tests can be determined statistically.

A number of methods of analyzing the data were examined, but it developed that the simple analysis described proved sufficient for the present. The analysis does not require replicate exposures; it is simple and it permits a wide range of exposures to be examined with a small number of badges. Replicate exposures would provide services with clues to the correct answers but much larger numbers of badges would be required. Further, with no replicates it is difficult for film badge services to anticipate the results.

The fact that the control limits adopted from this test are comparable with the interim control limits proposed by the Atomic Energy Commission in 1963 (*3*) should not be construed to mean that the control limits proposed by either the Foundation or the AEC represent satisfactory performance in personal dosimetry. The control limits reflect only the present level of performance of film badge services.

This and subsequent tests should enable film badge services to recognize and correct sources of error. As the services improve, the control limits may be narrowed. However, the extent to which they may be narrowed can be determined accurately only with data from additional testing.

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Table 3. Film badge performance control limits

Radiation category [b]	Irradiation range for test	Error factor control limits		Percentage error band [e]	
		Upper	Lower	Upper	Lower
X rays, 15–30 keV	20–600 mR	1.50	0.67	50	33
X rays, 0.03–0.2 MeV	20–600 mR	1.70	0.59	70	41
X rays, 0.15–0.2 MeV	1–500 R	1.60	0.63	60	37
Gamma, 0.2–3 MeV	20–600 mR	1.40	0.71	40	29
Beta	40–600 mrad	1.50	0.67	50	33
Beta of $\beta+\gamma$	40–600 mrad	2.00	0.50	100	50
Gamma [c] of $\beta+\gamma$	20–600 mR	1.40	0.71	40	29
X [d]+gamma [c]	20–600 mR	1.90	0.53	90	47
Fast neutron	50–600 mrem	2.00	0.50	100	50

[a] Energy ranges and types of radiation involved in the test are known to the film badge services but the type and energy of radiation delivered to a specific badge is unknown.

[b] Sources are described in detail in table 1.

[c] Gamma rays of 0.2 to 3 MeV energy.

[d] X rays of 15–30 keV.

[e] $1-[Y_e/X_e]\,100$.

Data

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1-3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; however, they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. In addition to the programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	July–December 1965	June 1966

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1. Pasteurized Milk Network
July 1966

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 issue of *Radiological Health Data* (*1*).

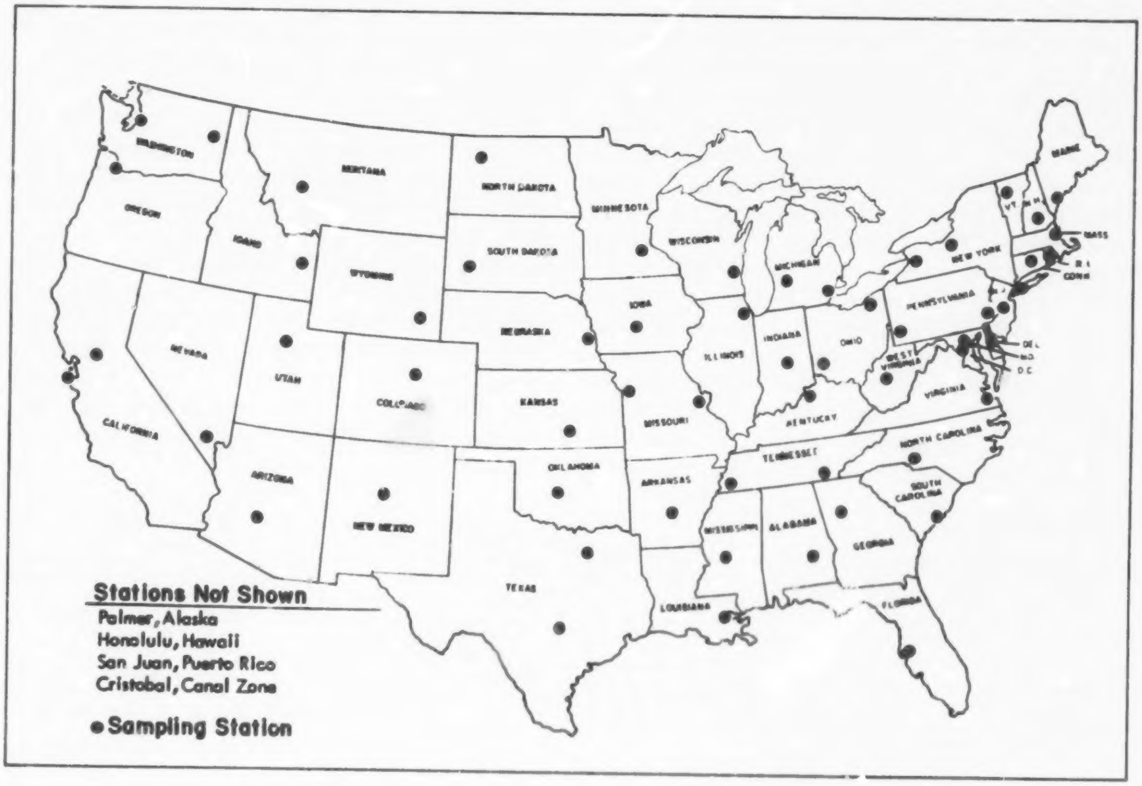
Washington
Oregon
California
Nevada
Idaho
Montana
Wyoming
Utah
Arizona
Colorado
New Mexico
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Minnesota
Iowa
Missouri
Arkansas
Louisiana
Wisconsin
Illinois
Michigan
Indiana
Ohio
Kentucky
Tennessee
Mississippi
Alabama
Georgia
Florida
South Carolina
North Carolina
Virginia
West Virginia
Pennsylvania
New York
Vt
N.H.
Maine
Mass
R.I.
Conn
Del
Md
D.C.
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
Cristobal, Canal Zone
● Sampling Station

Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average concentrations of radionuclides in pasteurized milk for the second quarter and July 1966[a]

Sampling location		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)		Barium-140 (pCi/liter)	
		Second quarter[b] 1966	July 1966	Second quarter 1966	July 1966	Second quarter 1966	July 1966	Second quarter 1966	July 1966	Second quarter 1966	July 1966
Ala:	Montgomery		<5	12	12	25	25	10	0	0	0
Alaska:	Palmer		<5	15	14	40	30	0	20	0	0
Ariz:	Phoenix		<5	3	3	10	10	0	0	0	0
Ark:	Little Rock		10	32	24	40	30	40	0	10	0
Calif:	Sacramento		<5	9	5	15	15	0	20	0	0
	San Francisco		<5	9	3	20	15	0	0	0	0
C.Z:	Cristobal		<5	4	4	20	15	0	0	0	0
Colo:	Denver		<5	11	8	25	20	0	0	0	0
Conn:	Hartford		<5	13	11	40	35	0	0	0	0
Del:	Wilmington		<5	17	13	40	30	0	0	0	0
D.C:	Washington		<5	13	12	30	25	0	0	0	0
Fla:	Tampa		<5	10	10	125	125	0	0	0	0
Ga:	Atlanta		5	20	19	40	40	10	0	0	0
Hawaii:	Honolulu		<5	6	5	30	20	0	0	0	0
Idaho:	Idaho Falls		<5	14	6	40	25	0	0	0	0
Ill:	Chicago		<5	13	9	35	25	0	0	0	0
Ind:	Indianapolis		5	13	11	30	20	20	0	0	0
Iowa:	Des Moines		5	16	15	30	20	16	0	0	0
Kans:	Wichita		<5	14	12	20	10	20	0	0	0
Ky:	Louisville		10	19	15	20	15	0	0	0	0
La:	New Orleans		10	32	37	45	65	0	0	0	0
Maine:	Portland		<5	16	18	70	60	0	0	0	0
Md:	Baltimore		<5	15	13	30	25	0	0	0	0
Mass:	Boston		<5	17	15	60	60	0	0	0	0
Mich:	Detroit		<5	12	9	30	25	0	0	0	0
	Grand Rapids		<5	16	14	45	35	0	0	0	0
Minn:	Minneapolis		5	23	21	40	35	0	0	0	0
Miss:	Jackson		10	26	22	30	30	10	0	0	0
Mo:	Kansas City		10	17	13	25	15	30	0	0	0
	St. Louis		15	19	17	30	25	30	0	0	0
Mont:	Helena		<5	14	12	55	30	0	0	0	0
Nebr:	Omaha		10	15	13	30	20	10	0	0	0
Nev:	Las Vegas		<5	6	4	25	10	0	0	0	0
N.H:	Manchester		<5	17	23	80	95	0	0	0	0
N.J:	Trenton		<5	13	12	30	25	0	0	0	0
N. Mex:	Albuquerque		<5	6	5	20	10	0	0	0	0
N.Y:	Buffalo		<5	12	11	40	25	0	0	0	0
	New York		<5	15	15	40	35	0	0	0	0
	Syracuse		<5	13	11	40	25	0	0	0	0
N.C:	Charlotte		5	20	21	30	30	20	0	0	0
N. Dak:	Minot		5	34	21	40	25	0	0	0	0
Ohio:	Cincinnati		<5	15	12	25	15	0	0	0	0
	Cleveland		<5	14	12	35	25	0	0	0	0
Okla:	Oklahoma City		<5	14	11	20	15	20	0	0	0
Ore:	Portland		<5	14	12	40	30	0	0	0	0
Pa:	Philadelphia		<5	14	13	35	25	0	0	0	0
	Pittsburgh		<5	19	19	45	25	0	0	0	0
P.R:	San Juan		<5	8	7	25	20	0	0	0	0
R.I:	Providence		<5	15	17	45	45	0	0	0	0
S.C:	Charleston		<5	21	21	50	55	20	0	0	0
S. Dak:	Rapid City		10	21	16	45	30	0	0	0	0
Tenn:	Chattanooga		5	21	20	30	30	0	0	0	0
	Memphis		5	19	16	20	15	20	0	0	0
Tex:	Austin		<5	6	5	15	10	0	0	0	0
	Dallas		<5	16	10	25	15	20	0	0	0
Utah:	Salt Lake City		<5	12	10	35	25	0	0	0	0
Vt:	Burlington		<5	14	15	50	40	0	0	0	0
Va:	Norfolk		<5	16	16	30	25	0	0	0	0
Wash:	Seattle		<5	18	23	55	65	0	0	0	0
	Spokane		<5	18	16	40	40	0	10	0	0
W. Va:	Charleston		<5	17	15	20	20	0	0	0	0
Wis:	Milwaukee		<5	10	9	40	25	0	0	0	0
Wyo:	Laramie		<5	12	11	30	30	0	0	0	0
Network average			<5	15.2	13.4	36	30	5	1	0	0

[a] Calcium analyses were discontinued as of March 1966.

[b] Quarterly averages are not reported since monthly averages for April were not calculated as only 10 percent of the samples were analyzed for strontium-89.

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Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, July 1965 and February–July 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965	1966					
	July	Feb	Mar	Apr	May	June	July
Under 10	8	9	9	8	10	9	14
10–19	34	46	44	50	38	41	39
20–29	18	7	7	3	12	10	9
30–39	3	1	3	2	3	3	1
40–49	0	0	0	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, July 1965 and February–July 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965	1966					
	July	Feb	Mar	Apr	May	June	July
Under 50	34	56	56	55	51	56	56
50–99	25	6	6	7	11	6	6
100–149	3	1	1	1	1	1	1
150–199	1	0	0	0	0	0	0
200–249	0	0	0	0	0	0	0

The results for July and the second quarter of 1966 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. However, because of the Chinese nuclear detonation, the sampling frequency was increased to twice a week from mid-May until the end of June. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for July 1965 and February through July 1966. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

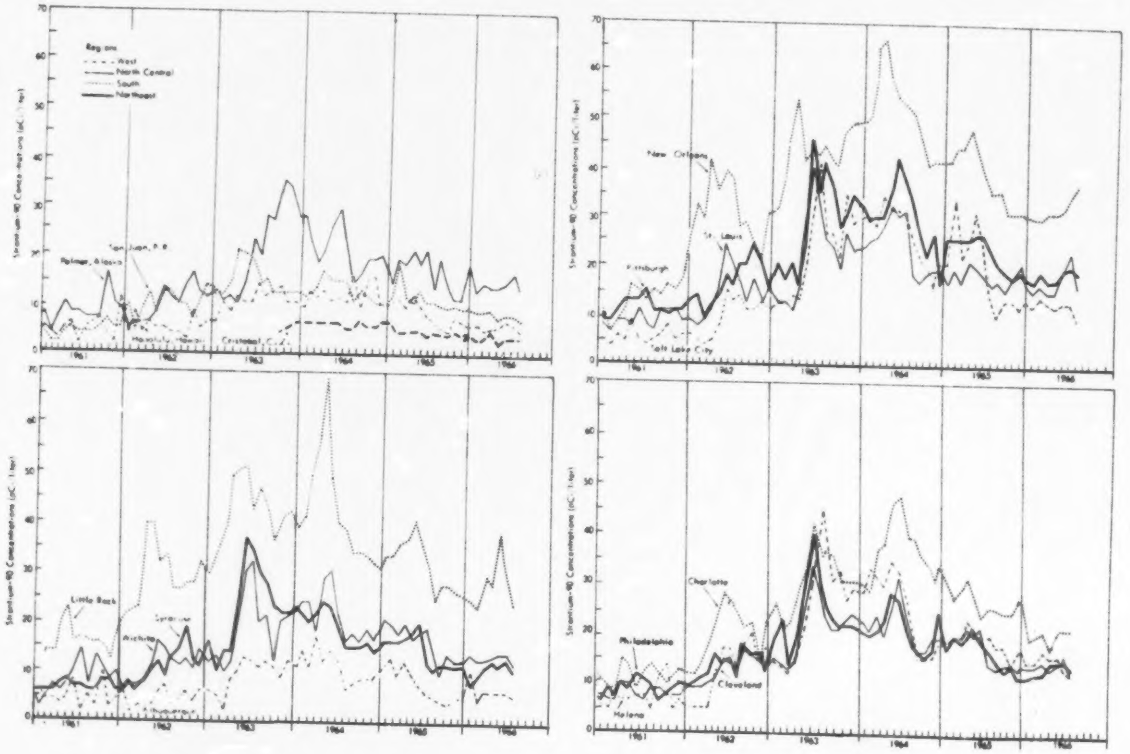

Figure 2. Strontium–90 concentrations in pasteurized milk 1961–July 1966

2. Canadian Milk Network
July 1966[1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (2).

The July 1966 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 4. Stable elements and radionuclides in Canadian whole milk, July 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.11	1.5	16	37
Edmonton	1.09	1.5	15	51
Ft. William	1.03	1.6	17	53
Fredericton	1.07	1.6	23	68
Halifax	1.11	1.6	20	59
Montreal	1.07	1.5	15	43
Ottawa	1.11	1.5	12	33
Quebec	1.07	1.6	21	56
Regina	1.09	1.5	15	32
St. John's, Nfld	1.09	1.6	44	167
Saskatoon	1.09	1.6	12	31
Sault Ste. Marie	1.09	1.6	24	59
Toronto	1.08	1.6	7	28
Vancouver	1.15	1.6	25	102
Windsor	1.12	1.6	15	19
Winnipeg	1.04	1.6	14	53
Average	1.09	1.6	18.4	56

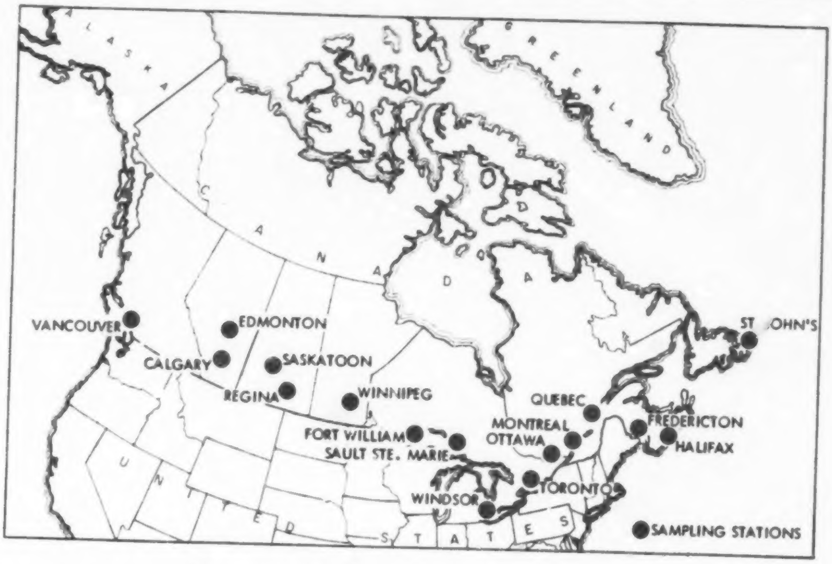

Figure 3. Canadian milk sampling stations

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[1] Prepared from July 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Milk Sampling Program July 1966

Pan American Health Organization and
U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*3*).

Table 5 presents stable calcium and potassium, strontium–89, strontium–90, iodine–131, cesium–137, and barium–140 monthly average concentrations for July 1966.

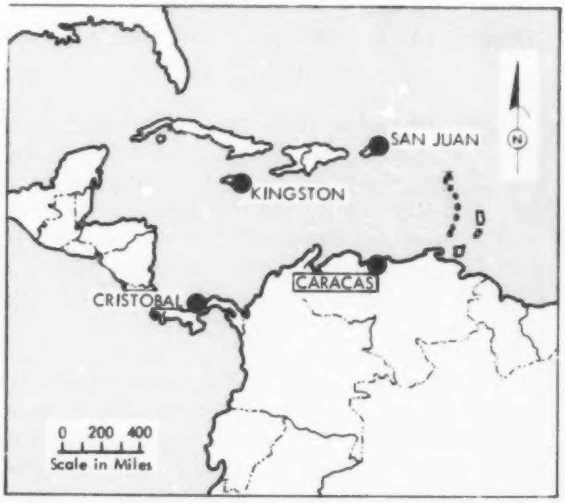

Figure 4. Pan American Milk Sampling Program locations

Table 5. Stable element and radionuclide concentrations in PAHO milk, July 1966

Sampling location	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Iodine-131 (pCi/liter)	Cesium-137 (pCi/liter)	Barium-140 (pCi/liter)
Ecuador:							
Guayaquil—							
Zone 1 [a] (9) [b]		1.58	<5	1	18	5	<10
Zone 2 (3)		1.49	<5	1	40	<5	<10
Zone 3 (2)		1.54	<5	2	<10	8	<10
Jamaica:							
Kingston	1.15	1.50	30	9	10	100	10
Mandeville	NS						
Montego Bay	NS						
Venezuela:							
Caracas (July)	1.10	1.55	<5	6	<10	5	10
June 1966[c]	1.08	1.45	<5	4	<10	10	<10
Canal Zone:							
Cristobal	—	—	<5	4	0	15	0
Puerto Rico:							
San Juan	—	—	<5	7	0	20	0

[a] Averages are calculated by the same method as that used for the Pasteurized Milk Sampling Network.
[b] Numbers in parentheses indicate number of samples.
[c] Data received too late for inclusion in October issue.
NS, no sample reported.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, August 1965. Radiol Health Data 6:677–681 (December 1965).

(*2*) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian Milk Network, August 1965. Radiol Health Data 6:685–686 (December 1965).

(*3*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Radiol Health Data 6:687 (December 1965).

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs supported by functional radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein are representative of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	Period reported	Last presented
California	January–March 1966	September 1966
Colorado	May 1965–June 1966	October 1966
Florida	April–June 1966	October 1966
Oklahoma	April–June 1966	October 1966
Oregon	January–March 1966	September 1966
Texas	April–June 1966	October 1966
Washington	January–March 1966	September 1966

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1. Connecticut Milk Network
April–June 1966

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium–89 and strontium–90 since April 1960. In May 1962, the program was expanded to include the determination of gamma-emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 1). At the present time, weekly samples representative of milk sold in the central area of the State are collected and analyzed for strontium–89, strontium–90, and gamma emitters. Concentrations of iodine–131 are determined as an indication of the presence of radioactivity of recent origin.

Strontium–89 and strontium–90 are determined by chemical separation. Iodine–131 and other gamma emitters are determined by gamma-scintillation spectrometry.

The monthly average concentrations of strontium–89, strontium–90, iodine–131, and cesium–137 in central Connecticut pasteurized milk are presented in table 1. Results obtained since 1962 are presented graphically in figure 2.

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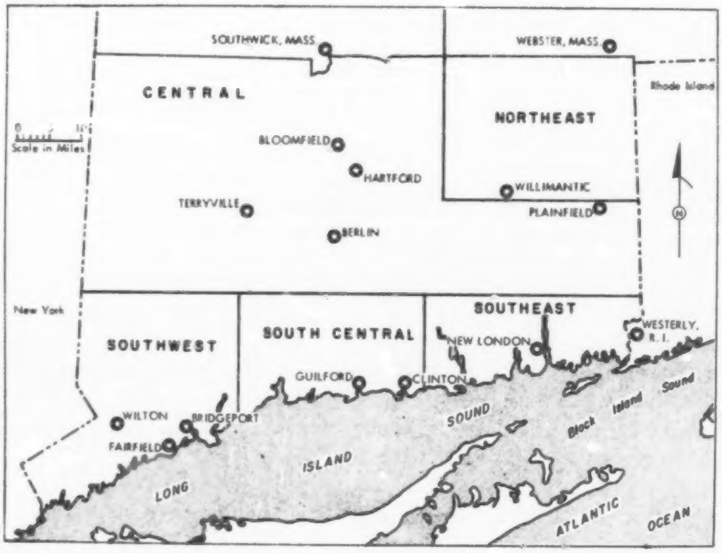
SOUTHWICK, MASS
WEBSTER, MASS
Rhode Island
CENTRAL
NORTHEAST
0 5 10
Scale in Miles
BLOOMFIELD
HARTFORD
WILLIMANTIC
PLAINFIELD
TERRYVILLE
BERLIN
N
New York
SOUTHWEST
SOUTH CENTRAL
SOUTHEAST
NEW LONDON
WESTERLY, R. I.
GUILFORD
CLINTON
WILTON
BRIDGEPORT
FAIRFIELD
SOUND
Block Island Sound
ISLAND
LONG
ATLANTIC
OCEAN

Figure 1. Connecticut pasteurized milk sampling areas

Table 1. Radionuclide concentrations in central Connecticut milk, April–June 1966

Month 1966	Concentration, pCi/liter			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
April	<1	10	<10	30
May	<1	10	<10	30
June	<1	14	<10	30

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
Annual summary 1963	September 1964
Annual summary 1964	May 1965
Annual summary 1965	May 1966
January–March 1966	August 1966

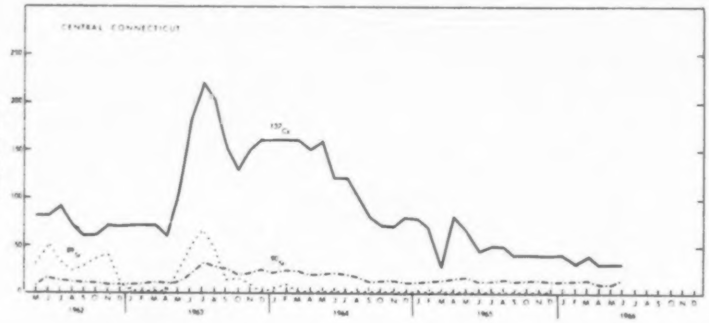

Figure 2. Radionuclide concentrations in central Connecticut pasteurized milk 1962–June 1966

2. Indiana Milk Network
April–June 1966

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. The State was geographically divided into five major milksheds: northeast, northwest, central, southeast, and southwest (figure 3). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are analyzed monthly for strontium-89 and strontium-90. Iodine-131, cesium-137, and barium-140 are analyzed weekly for at least two of the milksheds. When iodine-131 concentrations exceed 100 pCi/liter, the sampling frequency is increased. From August 1963 to April 1966, because of the continued low concentrations of short-lived radionuclides, the sampling frequency was once a month for northeast, southeast, and southwest milksheds.

Strontium-89 and strontium-90 concentrations in milk samples are determined by ion

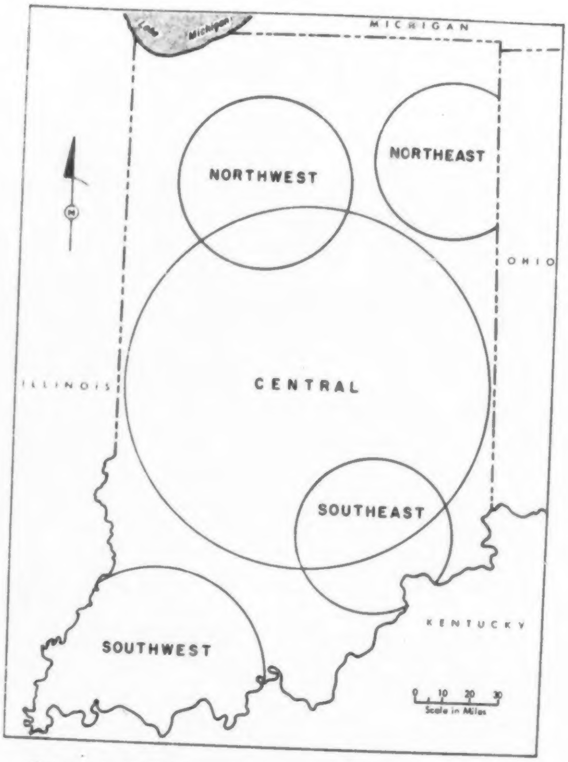

Figure 3. Indiana pasteurized milk sampling areas

Table 2. Radionuclides in Indiana milk, April–June 1966

Element and month	Sampling locations					
	North-east	South-east	Central	South-west	North-west	Average
Calcium (g/liter)						
April	1.20	1.20	1.17	1.20	1.17	1.19
May	1.16	1.14	1.14	1.14	1.14	1.14
June	1.20	1.18	1.20	1.18	1.20	1.19
Potassium-40 (pCi/liter)						
April	1,360	1,360	1,310	1,310	1,320	1,330
May	1,390	1,450	1,350	1,320	1,370	1,380
June	1,300	1,400	1,330	1,350	1,330	1,340
Strontium-89 (pCi/liter)						
April	0	0	0	0	0	0
May	0	0	0	0	0	0
June	5	10	25	5	10	10
Strontium-90 (pCi/liter)						
April	9	13	11	12	10	11
May	11	13	11	16	13	13
June	20	18	18	24	18	20
Iodine-131 (pCi/liter)						
April	0	0	0	0	0	0
May	40	35	70	20	100	50
June	10	10	40	10	40	20
Cesium-137 (pCi/liter)						
April	25	30	25	25	30	25
May	35	35	30	30	40	35
June	25	35	20	25	35	30
Barium-140 (pCi/liter)						
April	0	0	0	0	0	0
May	0	10	10	0	20	10
June	0	0	10	0	10	0

exchange separation (*1,2*), while iodine-131, cesium-137, and barium-140 are determined by gamma-scintillation spectrometry (*3*).

The monthly radionuclide concentrations in Indiana pasteurized milk are presented by geographical areas in table 2 for April through June 1966, and reflect the mainland China atmospheric nuclear test of May 9, 1966.

The monthly network average concentrations of strontium-89, strontium-90, and cesium-137 are presented graphically in figure 4.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
September-December 1964 and summaries 1961-1964	May 1965
Annual summary 1965	May 1966
January-March 1966	August 1966

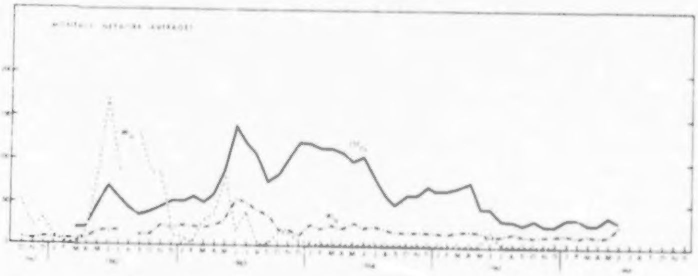

Figure 4. Radionuclide concentrations in Indiana pasteurized milk 1961-June 1966

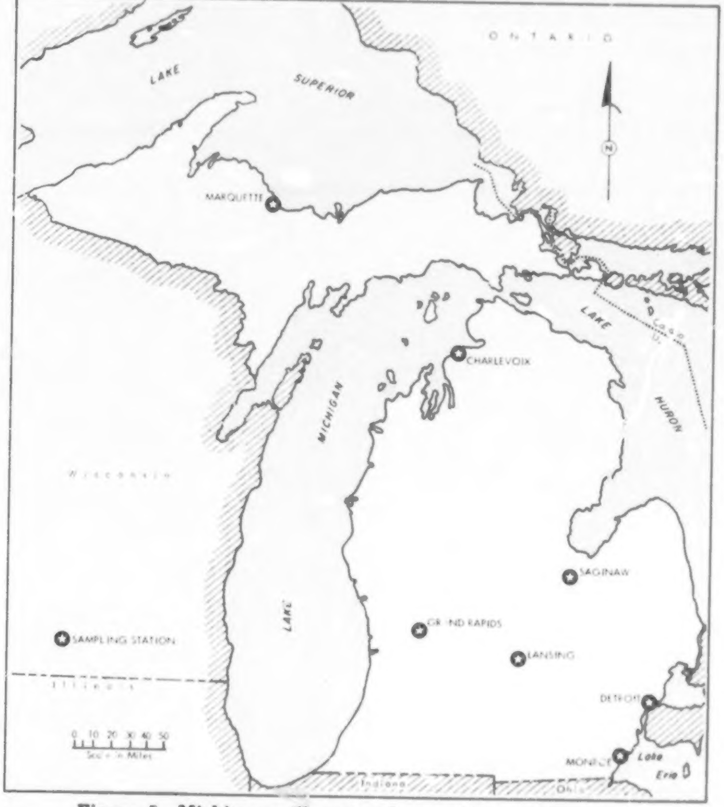
ONTARIO
LAKE
SUPERIOR
N
MARQUETTE
CHARLEVOIX
LAKE
HURON
MICHIGAN
WISCONSIN
SAGINAW
LAKE
GRAND RAPIDS
SAMPLING STATION
LANSING
ILLINOIS
DETROIT
0 10 20 30 40 50
Scale in Miles
MONROE
Lake
Erie
Indiana
Ohio

Figure 5. Michigan milk network sampling stations

3. Michigan Milk Network
January–June 1966

Division of Occupational Health
Michigan Department of Health

The Michigan Department of Health began sampling pasteurized milk for radionuclide analysis in November 1964. Under this program, weekly pasteurized milk samples are collected in the seven major milk-producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (figure 5). Milkshed samples are composites from dairies in proportion to sales volumes.

Strontium–90 concentrations are determined by an ion exchange method (4). Potassium–40, iodine–131, cesium–137, and barium-lanthanum–140 concentrations are determined by gamma-scintillation spectrometry (4).

Table 3 presents the monthly average radionuclide concentrations in Michigan pasteurized milk. Strontium–90 and cesium–137 concentrations since 1962 are presented graphically in figure 6, to show general trends.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
November 1962–December 1964	September 1965
January–June 1965	November 1965
July–December and annual summary 1965	May 1966

Table 3. Radionuclides in Michigan pasteurized milk, January–June 1966

Location	Month 1966	Concentrations, pCi/liter				
		Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
Charlevoix	January	1,370	15	<14	34	0
	February	1,380	13	<14	41	0
	March	1,370	11	<14	40	0
	April	1,380	12	<14	39	0
	May	1,390	NA	<14	36	0
	June	1,370	16	<10	33	0
Detroit	January	1,320	NA	<14	24	0
	February	1,350	8	<14	27	0
	March	1,360	7	<14	28	0
	April	1,340	6	<14	60	0
	May	1,360	NA	<14	29	0
	June	1,320	10	<14	23	0
Grand Rapids	January	1,350	NA	<14	34	0
	February	1,350	10	<14	38	0
	March	1,370	10	<14	40	0
	April	1,400	9	<14	44	0
	May	1,360	NA	<14	46	0
	June	1,340	13	<14	33	1
Lansing	January	1,350	8	<14	28	0
	February	1,330	8	<14	30	0
	March	1,380	7	<14	34	0
	April	1,320	6	<14	35	0
	May	1,320	NA	<14	36	0
	June	1,300	9	<14	24	0
Marquette	January	1,380	NA	<14	48	0
	February	1,370	18	<14	63	0
	March	1,370	19	<14	60	0
	April	1,380	NA	<14	61	0
	May	1,340	NA	<14	68	0
	June	1,340	NA	<14	58	1
Monroe	January	1,360	5	<14	19	0
	February	1,320	6	<14	22	0
	March	1,350	5	<14	23	0
	April	1,360	6	<14	29	0
	May	1,370	NA	<14	25	0
	June	1,370	10	<14	24	0
Saginaw	January	1,360	8	<14	23	0
	February	1,370	7	<14	29	0
	March	1,390	7	<14	31	0
	April	1,350	6	<14	34	0
	May	1,340	NA	<14	33	0
	June	1,310	11	<14	27	0
Average	January	1,360	9	<14	30	0
	February	1,350	10	<14	36	0
	March	1,370	9	<14	37	0
	April	1,360	8	<14	43	0
	May	1,350	NA	<14	39	0
	June	1,340	12	<14	32	0

NA, no analysis.

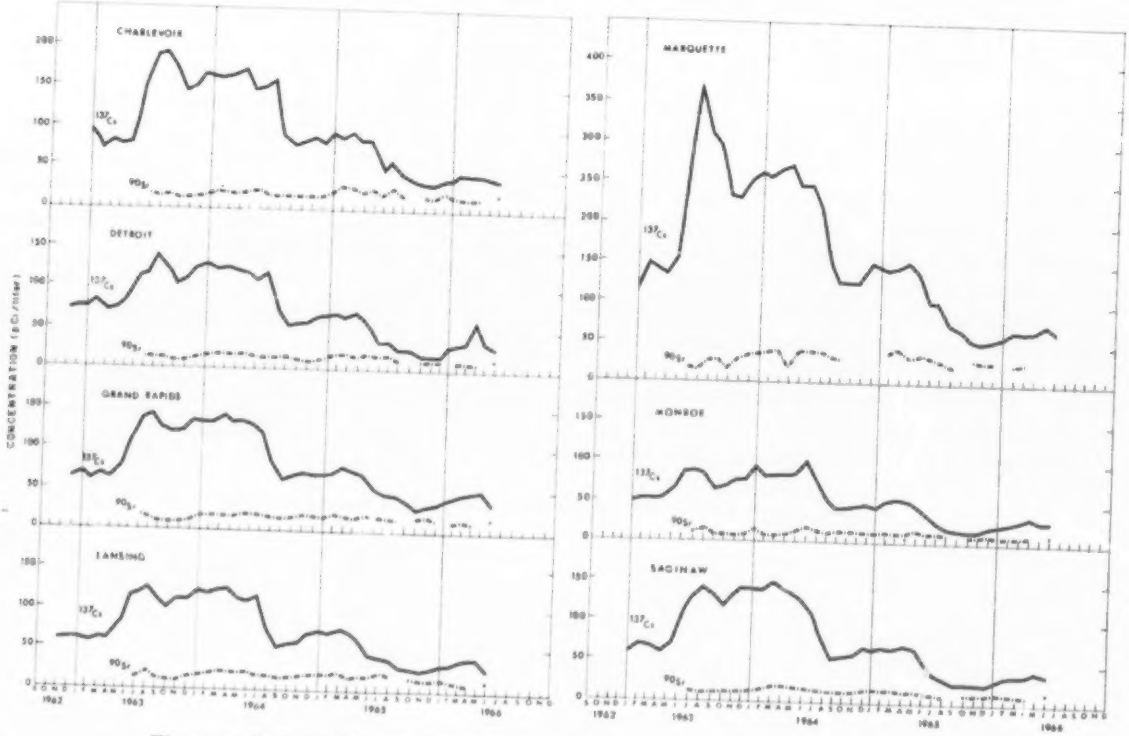

Figure 6. Radionuclide concentrations in Michigan pasteurized milk, 1962–June 1966

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4. Minnesota Milk Network April–June 1966

Division of Environmental Health
Minnesota Department of Health

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium-90 concentrations. Presently, monthly samples are collected from eight sampling locations in milksheds geographically the same as the Minnesota health districts (figure 7) and analyzed for strontium-90, iodine-131, and cesium-137. One-liter samples of processed Grade-A fluid milk are collected at bottling machines in pasteurization plants. The samples are customarily collected in the cities where the Minnesota Health Department district offices are located. However, it is sometimes convenient to collect at other locations. Such samples are considered representative of the district concerned.

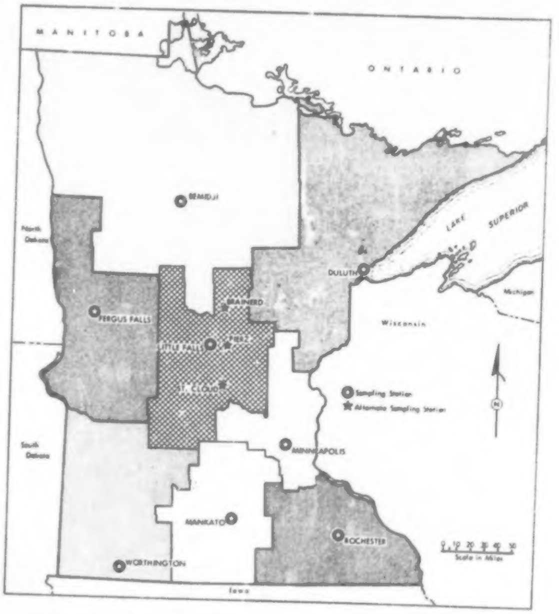
MANITOBA
ONTARIO
BEMIDJI
LAKE SUPERIOR
North Dakota
DULUTH
Michigan
BRAINERD
FERGUS FALLS
Wisconsin
LITTLE FALLS
ST. CLOUD
Sampling Station
Alternate Sampling Station
N
South Dakota
MINNEAPOLIS
MANKATO
ROCHESTER
WORTHINGTON
Scale in Miles
Iowa

Figure 7. Minnesota milk sampling locations

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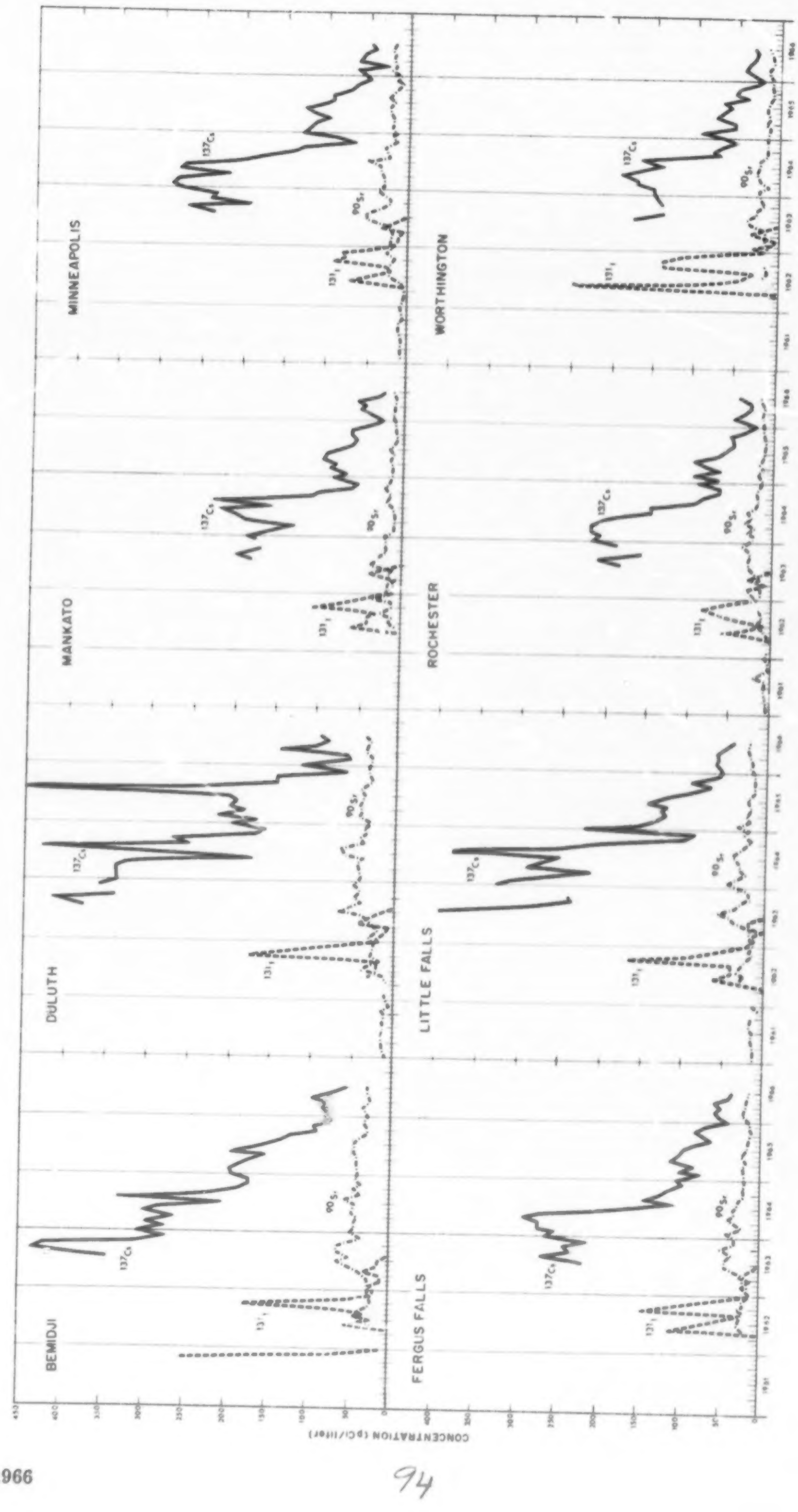

Figure 8. Radionuclide concentrations in Minnesota milk, 1961–June 1966

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Table 4. Radionuclide concentrations in Minnesota milk, April–June 1966

Sampling location	Month 1966	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Bemidji	April	26	97
	May	29	67
	June	30	53
Mankato	April	12	62
	May	11	30
	June	12	25
Rochester	April	9	46
	May	15	29
	June	16	28
Duluth	April	31	96
	May	26	79
	June	34	93
Worthington	April	12	32
	May	13	30
	June	14	34
Minneapolis	April	17	57
	May	22	41
	June	16	43
Fergus Falls	April	16	60
	May	14	37
	June	14	32
Little Falls	April	19	67
	May	21	54
	June	18	41
Average	April	18	65
	May	19	46
	June	19	44

Strontium–90 concentrations are determined radiochemically, while iodine–131 and cesium-137 concentrations are determined by gamma-scintillation spectrometry. The analytical procedures are presented in the semiannual report of the Minnesota Department of Health and the Rural Cooperative Power Association (5).

Strontium–90 and cesium–137 concentrations in milk are given for April through June 1966 in table 4, and iodine–131 concentrations in table 5. They are presented graphically by milkshed in figure 8, for the period 1962 through June 1966.

Table 5. Iodine-131 concentrations in Minnesota milk, April–June 1966

Collection point	Collection date 1966	Iodine-131 (pCi/liter)
Worthington	April 4	12
	May 1	13
	June 1	48
Mankato	June 1	51
Bemidji	June 6	12
Duluth	June 6	13
Little Falls	June 6	17
Rochester	June 6	24
Fergus Falls	June 8	13

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1964	July 1965
January–June 1965	January 1966
July–December and annual summary 1965	May 1966
January–March 1966	August 1966

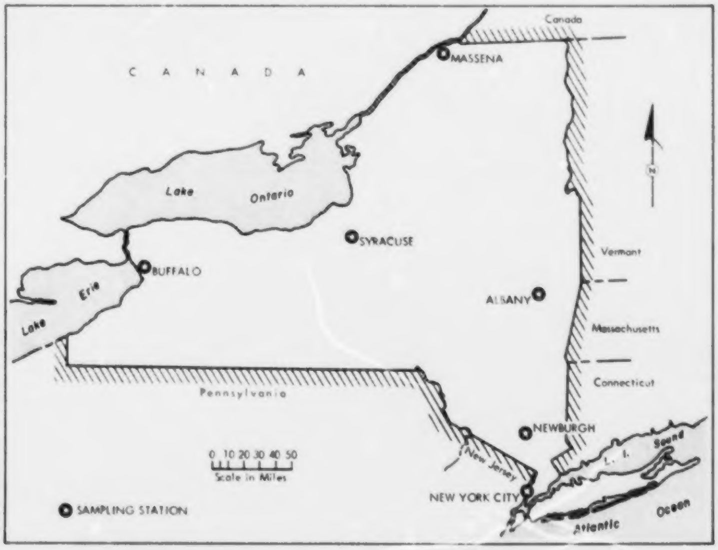
C A N A D A
Canada
MASSENA
Lake Ontario
SYRACUSE
BUFFALO
Lake Erie
ALBANY
Vermont
Massachusetts
Connecticut
Pennsylvania
NEWBURGH
New Jersey
NEW YORK CITY
L. I. Sound
Atlantic Ocean
N
0 10 20 30 40 50
Scale in Miles
SAMPLING STATION

Figure 9. New York milk sampling stations

5. New York Milk Network
January–June 1966

Division of Environmental Health Services
Department of Health, State of New York

Pasteurized milk samples collected routinely from six cities (figure 9) are analyzed for strontium–89, strontium–90, iodine–131, and barium-lanthanum–140 by the New York State Department of Health. At Buffalo, Newburgh, and Syracuse, milk samples are collected daily from processing plants, and composited weekly for radiochemical analysis. At Massena, samples are composited biweekly, while in New York City a milk sample representing the total milk supply for 1 day is obtained and composited weekly for analysis. The Albany sample, taken at a marketing point, is analyzed daily for iodine–131 and other gamma-emitting radionuclides before being composited into a weekly sample. In the event that any sample contains iodine–131 concentrations exceeding 100 pCi/liter, increased surveillance is undertaken.

Gamma-emitting radionuclides in milk are determined by scintillation spectrometry and the application of a matrix method of analysis (*6*) to the resultant spectral data.

The analytical procedure for determining strontium–89 and strontium–90 concentrations

Table 6. Strontium-89 concentrations in New York milk, January–June 1966

Sampling location	Strontium-89, pCi/liter					
	January	February	March	April	May	June
Albany	NA	NA	<3	<3	<3	6
Ashford	<3	NS	NS	NS	NS	NA
Bedford	NS	NS	NS	NS	NS	NS
Buffalo	<3	<3	NS	<3	<3	4
Clarktown	NS	NS	NS	NS	<3	<3
East Otto	NS	NS	NS	NA	NS	NS
Massena	NS	NS	NS	<3	<3	<3
Middleburg	NS	NS	<3	<3	<3	<3
Mount Pleasant	NS	NS	NS	NS	NS	NS
Newburgh	NS	NS	NS	<3	<3	5
New York	<3	7	NS	<3	<3	7
Oyster Bay	NS	NS	NS	NS	<3	<3
Syracuse	NS	NS	NS	<3	5	6
Yaphank	NS	NS	NS	NS	NS	NS
Yorkshire	NS	NS	NS	NS	NS	NS
Yorktown	NS	NS	NS	NS	NS	NS
Average	<3	5	<3	<3	<3	4

NA, no analysis.
NS, no sample collected.

Table 7. Strontium-90 concentrations in New York milk, January–June 1966

Sampling location	Strontium-90, pCi/liter					
	January	February	March	April	May	June
Albany	NA	NA	6	5	9	10
Ashford	12	NS	NS	NS	NS	NA
Bedford	NS	NS	NS	NS	NS	NS
Buffalo	8	14	NS	6	9	8
Clarktown	NS	NS	NS	NS	<3	10
East Otto	NS	NS	NS	NA	NS	NS
Massena	NS	NS	NS	9	9	12
Middleburg	NS	NS	8	9	8	9
Mount Pleasant	NS	NS	NS	NS	NS	NS
Newburgh	NS	NS	NS	9	9	14
New York	12	7	NS	14	13	16
Oyster Bay	NS	NS	NS	NS	9	10
Syracuse	NS	NS	NS	8	6	8
Yaphank	NS	NS	NS	NS	NS	NS
Yorkshire	NS	NS	NS	NS	NS	NS
Yorktown	NS	NS	NS	NS	NS	NS
Average	11	11	7	9	8	11

NA, no analysis.
NS, no sample collected.

Table 8. Iodine-131 concentrations in New York milk, January–June 1966

Sampling location	Iodine-131, pCi/liter					
	January	February	March	April	May	June
Albany	<20	<20	<20	<20	<20	<20
Ashford	NA	NS	NS	NS	NS	<20
Bedford	NS	NS	NS	NS	NS	NS
Buffalo	<20	<20	NS	<20	<20	<20
Clarktown	NS	NS	NS	NS	<20	<20
East Otto	NS	NS	NS	<20	NS	NS
Massena	NS	NS	NS	<20	<20	NS
Middleburg	NS	NS	<20	<20	<20	<20
Mount Pleasant	NS	NS	NS	NS	NS	NS
Newburgh	NS	NS	NS	<20	<20	<20
New York	<20	<20	NS	<20	<20	<20
Oyster Bay	NS	NS	NS	NS	<20	<20
Syracuse	NS	NS	NS	<20	<20	<20
Yaphank	NS	NS	NS	NS	NS	NS
Yorkshire	NS	NS	NS	NS	NS	NS
Yorktown	NS	NS	NS	NS	NS	NS
Average	<20	<20	<20	<20	<20	<20

NA, no analysis.
NS, no sample collected.

Table 9. Cesium-137 concentrations in New York milk, January–June 1966

Sampling location	Cesium-137, pCi/liter					
	January	February	March	April	May	June
Albany	24	26	30	37	31	26
Ashford	NA	NS	NS	NS	NS	28
Bedford	NS	NS	NS	NS	NS	NS
Buffalo	24	44	NS	52	29	<20
Clarktown	NS	NS	NS	NS	<20	<20
East Otto	NS	NS	NS	43	NS	NS
Massena	NS	NS	NS	55	53	NS
Middleburg	NS	NS	36	74	34	22
Mount Pleasant	NS	NS	NS	NS	NS	NS
Newburgh	NS	NS	NS	<20	<20	<20
New York	43	22	NS	36	38	38
Oyster Bay	NS	NS	NS	NS	56	47
Syracuse	NS	NS	NS	22	37	23
Yaphank	NS	NS	NS	NS	NS	NS
Yorkshire	NS	NS	NS	NS	NS	NS
Yorktown	NS	NS	NS	NS	NS	NS
Average	30	31	33	42	40	28

NA, no analysis.
NS, no sample collected.

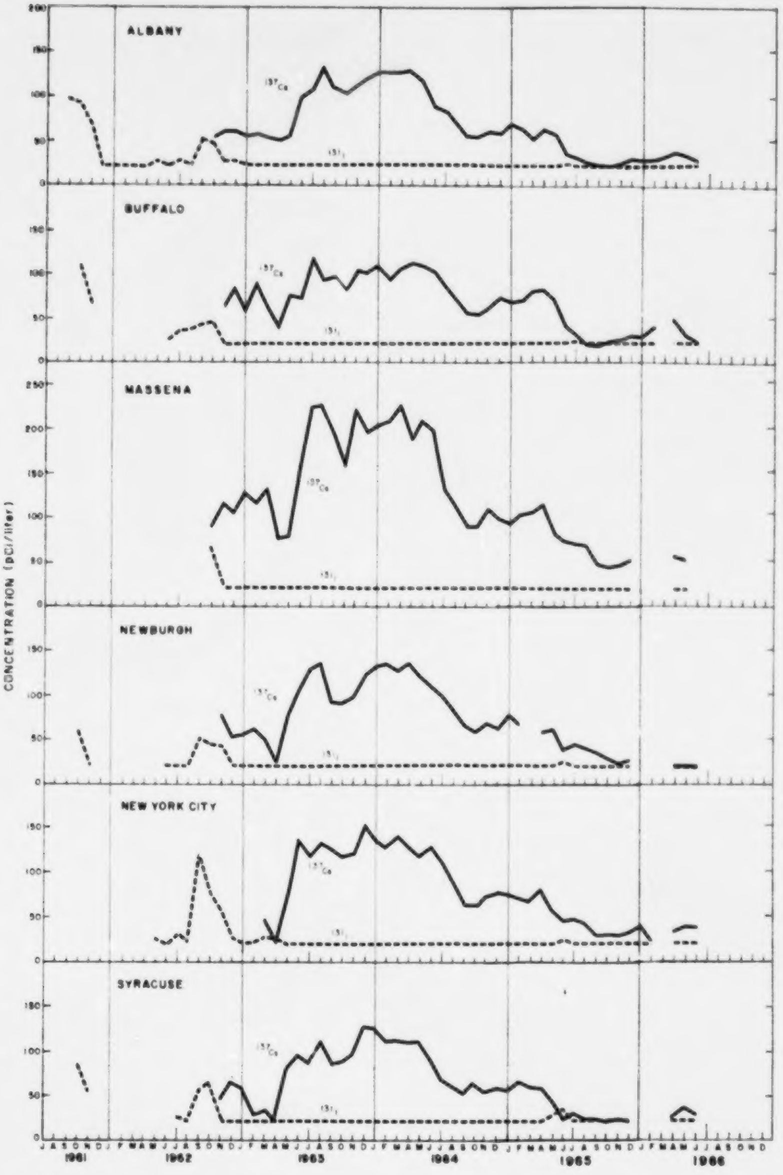

Figure 10. Radionuclide concentrations in New York milk, 1961–June 1966

employs an ion exchange system similar to that developed by Porter and Kahn (*2*).

The monthly average radionuclide concentrations of strontium-89 (table 6), strontium-90 (table 7), iodine-131 (table 8), and cesium-137 (table 9) are shown for January through June 1966. Iodine-131 and cesium-137 concentrations since September 1961 are presented graphically in figure 10.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
July–September 1964	April 1965
October–December 1964	May 1965
Annual summary 1965	May 1966

6. Pennsylvania Milk Network
April–June 1966

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 11). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location, subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health, in Harrisburg, where the weekly samples are combined for monthly analysis. Strontium-90 analyses have been carried out since April 1963.

The chemical separation technique for strontium-90 is essentially an ion exchange method described by Porter and Kahn (*2*).

The monthly average potassium-40, strontium-90, iodine-131, and cesium-137 concentrations in pasteurized milk are given in table 10. For comparative purposes, strontium-90, iodine-131, and cesium-137 concentrations are presented graphically in figure 12.

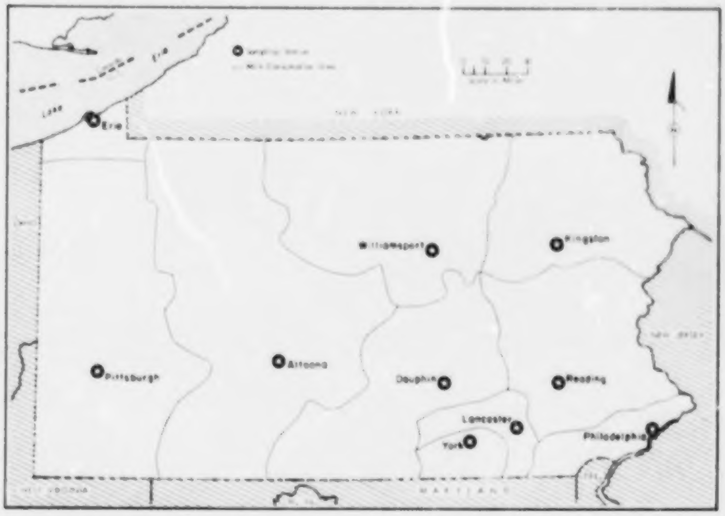

Figure 11. Pennsylvania pasteurized milk network sampling locations

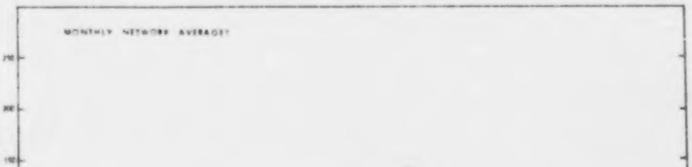

Figure 12. Radionuclide concentrations in Pennsylvania pasteurized milk, 1962–June 1966

Table 10. Radionuclide concentrations in Pennsylvania milk, April–June 1966

Sampling location	Month	Concentrations, pCi/liter			
		Potassium-40	Strontium-90	Iodine-131	Cesium-137
Altoona	April	850	15	<10	32
	May	800	22	<10	24
	June	910	14	10	27
Dauphin	April	865	12	<10	26
	May	810	14	<10	37
	June	880	16	10	22
Erie	April	885	25	<10	49
	May	926	22	<10	55
	June	890	30	10	38
Kingston	April	893	15	<10	32
	May	918	25	<10	35
	June	890	27	10	50
Lancaster	April	910	10	<10	24
	May	905	15	<10	33
	June	899	16	10	23
Philadelphia	April	750	10	<10	28
	May	894	13	<10	33
	June	900	11	10	26
Pittsburgh	April	896	21	<10	41
	May	928	29	<10	45
	June	882	20	10	36
Reading	April	920	12	<10	26
	May	919	17	<10	27
	June	800	12	10	30
Williamsport	April	825	15	<10	28
	May	792	14	<10	25
	June	790	18	15	29
York	April	900	13	<10	32
	May	891	16	<10	21
	June	890	14	10	28
Average	April	569	15	<10	32
	May	878	19	<10	34
	June	874	18	11	31

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
August–September 1964	February 1965
Annual summary 1964	June 1965
Annual summary 1965	May 1966
January–March 1966	August 1966

REFERENCES

(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Determination of strontium-90 in milk by an ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(*2*) PORTER, C., and B. KAHN. Improved determinations of strontium-90 in milk by an ion-exchange method. Anal Chem 36:676–678 (March 1964).

(*3*) INDIANA STATE BOARD OF HEALTH, BUREAU OF ENVIRONMENTAL SANITATION. Indiana milk network, April–June 1965. Radiol Health Data 6:612–614 (November 1965).

(*4*) MICHIGAN DEPARTMENT OF HEALTH. Michigan milk network, November 1962–December 1964. Radiol Health Data 6:487–492 (September 1965).

(*5*) MINNESOTA DEPARTMENT OF HEALTH and RURAL COOPERATIVE POWER ASSOCIATION. Survey of environmental radioactivity, January–June 1965, semiannual report, COO–615–17. Minnesota Department of Health, Minneapolis, Minnesota (August 1965).

(*6*) KAHN, B., G. K. MURTHY, C. PORTER, G. R. HAGEE, G. J. KARCHES, and A. S. GOLDIN. Rapid methods for estimating fission product concentrations in milk, PHS Publication No. 999–R–2 (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health and Reports* and not covered in this issue are listed below:

Program	Period reported	Last presented
California Diet	September–December 1965	September 1966
Institutional Diet, PHS	January–March 1966	October 1966
Teenage Diet, FDA	February–November 1965	August 1966
Tri-City Diet, HASL	November 1965–January 1966	September 1966

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1. Estimated Daily Intake of Radionuclides in Connecticut Standard Diet, July 1965–June 1966

Connecticut State Department of Health

The Connecticut State Department of Health has been analyzing a standard diet on a monthly basis since March 1963. These analyses included strontium–89, strontium–90, and gamma-emitting radionuclides.

The standard diet was selected to represent the food intake of an 18-year-old boy for 1 day (table 1). The total weight of the complete blended diet, averaging 3 kilograms, included milk and dairy products. When raw fruit or vegetables were sampled, they were washed before blending.

Cesium–137 concentrations were determined by gamma-scintillation spectrometry (*1*). Strontium–89 and strontium–90 concentrations were determined by a chemical separation technique (*1*).

Table 2 presents the analytical results for the Connecticut standard diet from July 1965 through June 1966.

Results representative of the total daily intake for the radionuclides observed are presented in table 3.

In order to evaluate general trends, the strontium–90 and cesium–137 daily intakes from 1963 to the present are plotted as a function of time in figures 1 and 2.

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Table 1. Foods included in standard diet

Bread, white—8 slices
Butter—½ stick
Carrots, scraped—½ cup
Celery, washed and trimmed—3 stalks
Cookies—4
Cottage cheese—⅓cup
Cupcakes—2
Egg—1
Green beans, washed—½ cup
Ham—85 grams
Hamburger—227 grams
Ice cream—½ pint
Lettuce, washed—4-5 leaves
Milk—3 cups
Oatmeal, uncooked—43 grams
Orange—1
Peanut butter—2½ tablespoons
Pears, canned—2 halves with juice
Potatoes, washed, not peeled—2
Sugar—5 tablespoons
Tomato juice—113 grams
Tuna fish, drained—43 grams

Table 2. Radionuclide concentrations in Connecticut standard diet, July 1965–June 1966 [a]

Month	Potassium (g/kg)	Strontium-90 (pCi/kg)	Cesium-137 (pCi/kg)
1965			
July	2.0	NA	60
August	2.0	13.9	70
September	2.2	12.7	50
October	2.2	16.3	60
November	2.2	11.0	50
December	2.2	11.3	30
1966			
January	2.1	10.7	50
February	2.3	12.4	30
March	2.4	12.3	60
April	2.4	14.1	40
May	2.4	10.4	30
June	2.3	16.3	40

[a] All strontium-89 values <3 pCi/kg for this period.
NA, no analysis performed.

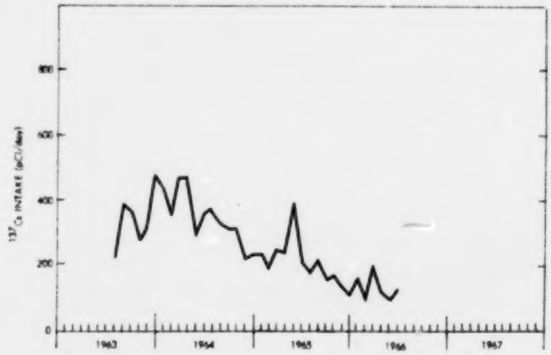

Figure 1. Cesium-137 intake in Connecticut standard diet 1963–June 1966

Table 3. Daily radionuclide intakes in Connecticut standard diet, July 1965–June 1966 [a]

Month	Potassium (g/day)	Strontium-90 (pCi/day)	Cesium-137 (pCi/day)
1965			
July	5.7	NA	180
August	6.2	43.1	220
September	6.8	39.2	160
October	6.5	47.9	170
November	6.6	33.4	140
December	7.1	37.0	110
1966			
January	6.2	31.8	160
February	7.4	40.8	90
March	7.4	38.3	200
April	7.3	42.3	130
May	7.4	31.9	100
June	7.3	51.5	130

[a] All strontium-89 values <3 pCi/day for this period.
NA, no analysis performed.

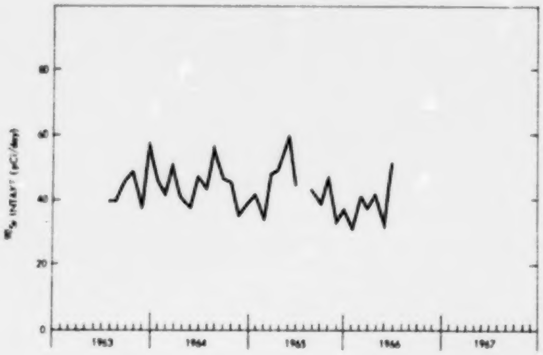

Figure 2. Strontium-90 intake in Connecticut standard diet 1963–June 1966

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
March 1963–December 1964	July 1965
January–June 1965	February 1966

REFERENCE

(*1*) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963–December 1964. Radiol Health Data 6:381–382 (July 1965).

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross alpha and gross beta radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity, except when more complete analysis indicates that concentrations of nuclides are not likely to cause exposures greater than the Radiation Protection Guides. Surveillance data from a number of Federal and State programs published periodically in *Radiological Health Data and Reports* are listed below:

Program	Period reported	Last presented
Colorado River Basin Sampling Network	1962–1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Minnesota Surface Water Sampling Program	July–December 1965	July 1966
New York Water Sampling Program	June–December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Radiostrontium in Tap Water, HASL	May and July–November 1965	June 1966
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, MAY 1966

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta analyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.

Special note is taken when the alpha radio-

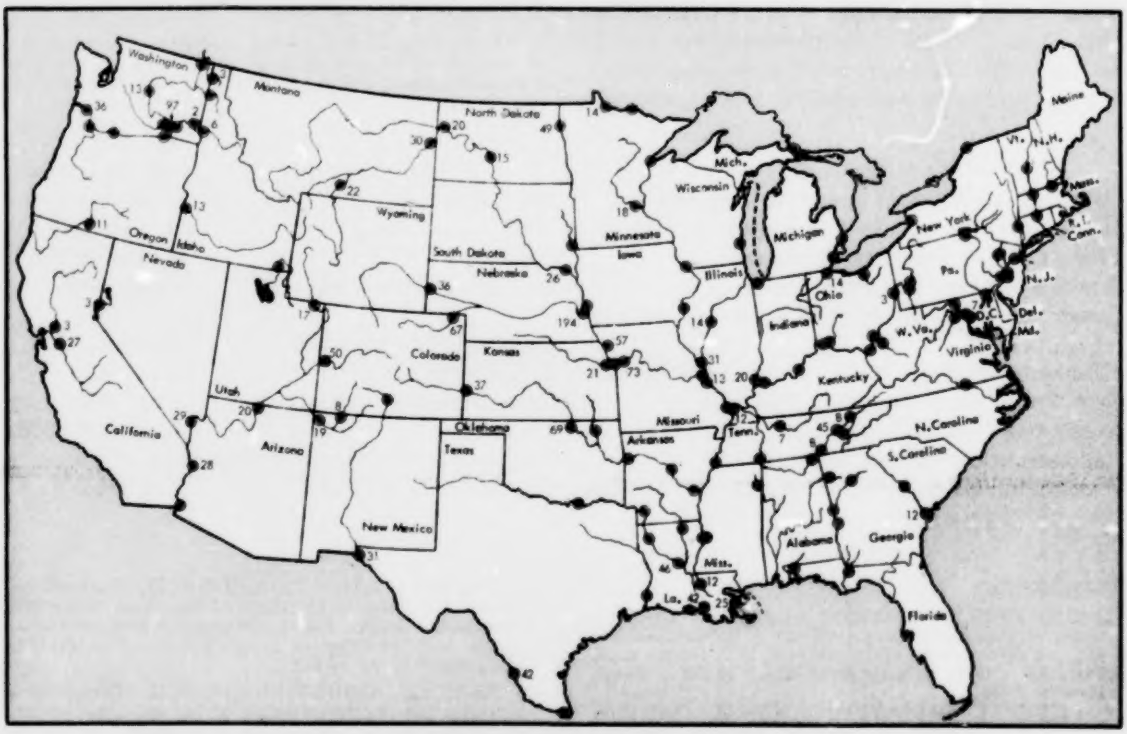
Washington
Montana
North Dakota
Minnesota
Wisconsin
Mich.
Michigan
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
New York
Pa.
N.J.
Del.
Md.
D.C.
Virginia
W.Va.
Ohio
Indiana
Illinois
Iowa
Kentucky
Tenn.
N.Carolina
S.Carolina
Georgia
Alabama
Miss.
La.
Florida
Arkansas
Missouri
Kansas
Oklahoma
Texas
New Mexico
Colorado
Nebraska
South Dakota
Wyoming
Idaho
Oregon
Nevada
California
Utah
Arizona
13
36
97
2
6
30
20
49
15
14
22
13
11
18
3
3
27
17
50
36
26
67
194
57
21
73
37
20
8
19
29
28
69
14
31
13
20
12
7
45
6
8
14
3
7
12
46
12
42
25
31
42

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, May 1966

activity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During April and May the following stations showed alpha radioactivity in excess of 15 pCi/liter on dissolved solids:

North Platte River: Henry, Nebraska
South Platte River: Julesburg, Colorado

Coolidge, Kansas, on the Arkansas River, dropped to 12 pCi/liter of alpha radioactivity

Table 1. Radioactivity in raw surface waters, May 1966

Stations	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	4	4	8	1	1	2
Arkansas River:						
Coolidge, Kans	3	34	37	<1	12	12
Ponca City, Okla	38	31	69	6	3	9
Atchafalaya River:						
Morgan City, La	34	8	42	9	1	10
Big Horn River:						
Hardin, Mont	3	19	22	<1	10	10
Chena River:						
Fairbanks, Alaska	8	5	13	1	1	2
Clearwater River:						
Lewiston, Idaho	4	2	6	<1	0	<1
Clinch River:						
Clinton, Tenn	5	3	8	1	0	1
Kingston, Tenn [a]	2	43	45	0	<1	<1
Colorado River:						
Loma, Colo	37	13	50	10	4	14
Page, Ariz	<1	20	20	0	6	6
Boulder City, Nev	1	28	29	0	10	10
Parker Dam, Calif-Ariz	1	27	28	0	9	9
Columbia River:						
Wenatchee, Wash	10	3	13	0	0	0
Pasco, Wash [a]	45	52	97	<1	1	1
Clatskanie, Ore	7	29	36	0	0	0
Cumberland River:						
Cheatham Lock, Tenn	3	4	7	1	0	1
Green River:						
Dutch John, Utah	1	16	17	0	3	3
Illinois River:						
Peoria, Ill	3	11	14	1	1	2
Grafton, Ill	4	27	31	0	2	2
Kansas River:						
DeSoto, Kans	2	19	21	1	2	3
Klamath River:						
Keno, Ore	1	10	11	0	<1	<1
Maumee River:						
Toledo, Ohio	2	12	14	1	1	2
Mississippi River:						
St. Paul, Minn	2	16	18	0	2	2
E. St. Louis, Ill	2	11	13	1	1	2
New Roads, La	3	9	12	0	0	0
New Orleans, La	16	9	25	4	0	4
Missouri River:						
Williston, N. Dak	6	14	20	2	4	6
Bismarck, N. Dak	1	14	15	0	2	2
Yankton, S. Dak	1	25	26	0	4	4
St. Joseph, Mo	37	20	57	5	4	9
Kansas City, Kans	50	23	73	10	5	15
North Platte River:						
Henry, Nebr	2	34	36	<1	19	19
Ohio River:						
Toronto, Ohio	0	3	3	0	0	0
Cairo, Ill	4	8	12	1	0	1
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	3	3	0	<1	<1
Platte River:						
Plattsmouth, Nebr	171	23	194	43	5	48
Potomac River:						
Washington, D.C	3	4	7	1	0	1
Rainy River:						
Baudette, Minn	3	11	14	<1	0	<1
Red River, North:						
Grand Forks, N. Dak	11	38	49	1	4	5
Red River, South:						
Alexandria, La	37	9	46	7	0	7
Rio Grande:						
El Paso, Tex	11	20	31	3	3	6
Laredo, Tex	28	14	42	10	3	13
Sacramento River:						
Greens Landing, Calif	1	2	3	0	0	0
San Joaquin River:						
Vernalis, Calif	13	14	27	3	9	12
San Juan River:						
Shiprock, N. Mex	11	8	19	4	3	7
Savannah River:						
Port Wentworth, Ga [a]	2	10	12	0	0	0
Snake River:						
Payette, Idaho	2	11	13	<1	4	4
Wawawai, Wash	0	2	2	0	0	0
South Platte River:						
Julesburg, Colo	2	65	67	0	40	40
Tennessee River:						
Chattanooga, Tenn	1	7	8	0	0	0
Truckee River:						
Farad, Calif	1	2	3	0	0	0
Wabash River:						
New Harmony, Ind	8	12	20	2	1	3
Yellowstone River:						
Sidney, Mont	19	11	30	5	3	8
Maximum	171	65	194	43	40	48
Minimum	0	2	2	0	0	0

[a] Gross beta activity at this station may not be directly comparable to gross beta activity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides common to all stations.

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on dissolved solids. Plattsmouth, Nebraska, on the Platte River showed an increase in alpha radioactivity on suspended solids to greater than 15 pCi/liter.

During May, Pasco, Washington, on the Columbia River, has decreased in beta radioactivity on dissolved solids to less than 150 pCi/liter. At Kingston, Tennessee, on the Clinch River, the beta radioactivity on dissolved solids has decreased to nearly normal levels for the monthly average as well as for all of the weekly samples.

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(2) *Ibid.*, 1959 Edition.
(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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RADIONUCLIDE ANALYSIS OF COAST GUARD WATER SUPPLIES JANUARY-DECEMBER 1965

U.S. Coast Guard[1] *and*
Division of Radiological Health[2]

Beginning in October 1961, 1-gallon samples of water have been obtained from seven Coast Guard Loran Stations in Alaska (figure 1).

The prime source of potable water at the Adak Loran Station is Alpine Lake, which is at an elevation of 1,000 feet. The lake is occasionally frozen over with little snow cover each year from December through April. Water is delivered from the lake as needed through a 2-mile pipe line to three 25,000-gallon concrete reservoirs. All water is chlorinated at the station before use.

The Attu Loran Station's prime source of potable water is Alout Creek Dam and reservoir. This water source is usually frozen over from November through April, with a frequent snow cover of 1 to 3 feet. A 1-mile pipe line feeds water by gravity to three 25,000-gallon concrete reservoirs at the station. The water is chlorinated before use.

The Biorka Loran Station's water comes from a lake that is often frozen over lightly from January to March. The water is fed by

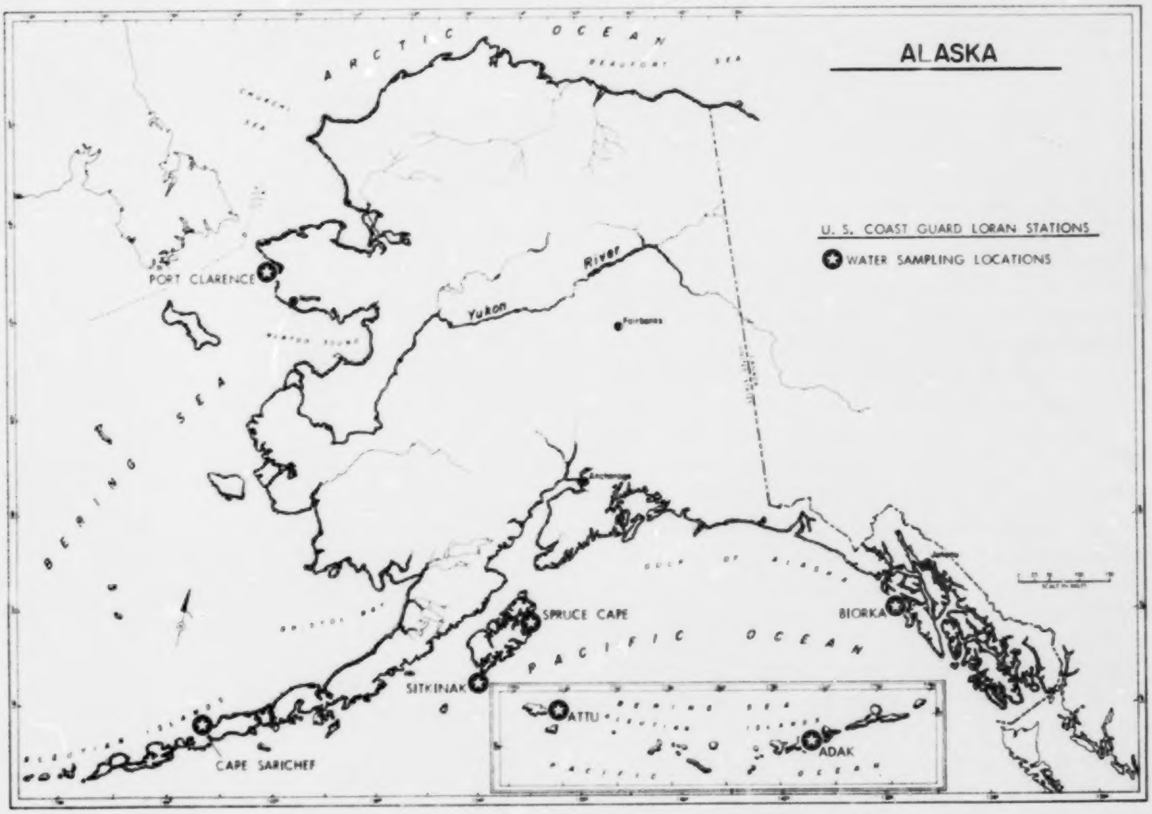
ARCTIC OCEAN
ALASKA
U. S. COAST GUARD LORAN STATIONS
WATER SAMPLING LOCATIONS
PORT CLARENCE
Yukon River
Fairbanks
BERING SEA
GULF OF ALASKA
BIORKA
SPRUCE CAPE
PACIFIC OCEAN
SITKINAK
ATTU
ADAK
CAPE SARICHEF

Figure 1. Coast Guard Loran station water sampling locations

gravity through a 1-mile-long insulated pipe to a pump house. From there it is pumped another mile to a 25,000-gallon steel storage tank from which it is fed by gravity one-half mile to the station, filtered, and chlorinated.

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[1] U.S. Department of the Treasury
[2] U.S. Public Health Service

The source of water for the Cape Sarichef Loran Station is a small dammed creek and reservoir. The reservoir is usually frozen over from December through April, with 1 to 3 feet of snow cover during that period. The water is pumped 1½ miles from the dam to a 25,000-gallon steel storage tank above ground, from which the water is fed by gravity to the station, filtered and chlorinated.

The Sitkinak Loran Station obtains its water from a natural lake which is normally frozen over from December through April, with 3 to 12 inches of snow cover during that period. The water is pumped from the lake through a 1,500-foot line to three 25,000-gallon concrete reservoirs at the station. The water is filtered and chlorinated as used.

Port Clarence Loran Station's source of water is two shallow, flatland lakes, which freeze solid to their depth of 1½ to 3 feet from November through May. A variable snow cover of 1 to 5 feet is normal during this period. The water is pumped beneath the ice and seasonal frost to the station's concrete cisterns of 225,000-gallon capacity. Normally the entire capacity of the station's tanks is topped off prior to December 1 and only a small amount of water is pumped from the lake area after that date, depending on the thickness of snow, ice, and frost cover during the winter months. At the time of the first thaw, usually in May, the station tanks are again filled and kept filled until the following winter freeze. All water is filtered and chlorinated before use.

A natural hillside lake is Spruce Cape Loran Station's source of water. The lake is generally ice-free throughout the entire winter season with only light snowfall and general slush. The water is pumped one-half mile from the lake to a 25,000-gallon wood-stave cistern from which it is fed by gravity to the station, filtered, and chlorinated.

Water samples are analyzed for gross alpha, gross beta, barium-lanthanum–140, cesium–137, iodine–131, ruthenium–103, ruthenium–106, and zirconium-niobium–95. The radionuclide analyses are performed by gamma spectrometry. All analyses are performed by the Southwestern Radiological Health Laboratory, Las Vegas, Nevada. The results of the gross alpha and beta analyses are reported in table 1. Values for specific radionuclide content are not reported, since in all cases they were below the respective minimum detectable levels (cesium–137, 5 pCi/liter; all others, 10 pCi/liter).

Table 1. Radioactivity in water samples from U.S. Coast Guard Loran stations January–December 1965

Alaskan location	Collection date 1965	Gross alpha (pCi/liter)	Gross beta (pCi/liter)
Adak	February 23	NA	3
Attu Island	May 7	0.1	13
	June 4	<0.1	8
	July 13	0.4	4
	July 15	0.3	6
Biorka Island	January 13	NA	23
	January 19	NA	3
	January 26	NA	5
	February 16	NA	24
	February 23	NA	26
	March 16	<0.1	14
	March 24	<0.1	7
	March 30	<0.1	18
	April 5	<0.1	11
	April 13	<0.1	3
	May 17	<0.1	17
Cape Sarichef	February 11	NA	3
	March 9	<0.1	2
	April 23	<0.1	8
	May 18	<0.1	3
	June 4	<0.1	2
	July 6	0.2	2
	August 12	<0.1	4
Port Clarence	January 16	NA	14
	February 1	NA	2
	February 18	NA	12
	March 12	0.8	8
	April 8	1.1	28
	May 6	1.1	18
	June 3	1.9	14
	July 6	0.2	5
	August 3	<0.1	18
Sitkinak Island	January 13	NA	3
	February 13	NA	16
	March 9	0.3	20
	April 8	<0.1	17
	May 10	<0.1	16
	May 16	<0.1	5
	July 6	0.4	20
	July 15	<0.1	7
Spruce Cape	January 12	<0.1	<1
	March 8	0.2	4
	March 29	0.8	11
	April 6	<0.1	11
	May 3	<0.1	7
	June 24	<0.1	4
	July 23	<0.1	15
Maximum		1.9	28
Minimum		<0.1	<1

NA, no analysis performed.

Previous coverage in *Radiological Health Data*:

Period	Issue
October 1961–April 1962	October 1962
May–December 1962	August 1963
January–December 1963	November 1964
January–December 1964	November 1965

RADIOACTIVITY IN CALIFORNIA WATERS JULY-DECEMBER 1965[1]

Bureau of Radiological Health
State of California Department
of Public Health

Gross beta activity in California domestic waters is monitored by the State of California's Bureau of Radiological Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters and well waters. It should be noted that except for large metropolitan water supplies, raw water sampling is

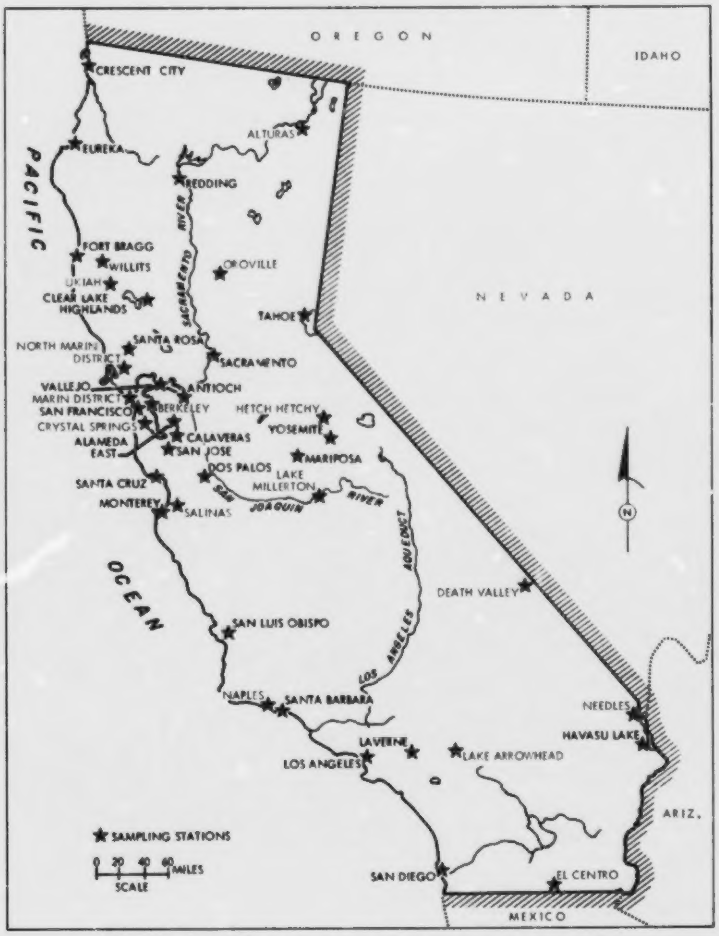
OREGON
IDAHO
NEVADA
ARIZ.
MEXICO
PACIFIC
OCEAN
CRESCENT CITY
EUREKA
ALTURAS
REDDING
SACRAMENTO RIVER
FORT BRAGG
WILLITS
UKIAH
CLEAR LAKE HIGHLANDS
OROVILLE
TAHOE
NORTH MARIN DISTRICT
SANTA ROSA
SACRAMENTO
VALLEJO
ANTIOCH
MARIN DISTRICT
SAN FRANCISCO
BERKELEY
HETCH HETCHY
CRYSTAL SPRINGS
YOSEMITE
CALAVERAS
ALAMEDA EAST
SAN JOSE
MARIPOSA
DOS PALOS
LAKE MILLERTON
SANTA CRUZ
MONTEREY
SALINAS
SAN JOAQUIN RIVER
LOS ANGELES AQUEDUCT
N
DEATH VALLEY
SAN LUIS OBISPO
NAPLES
SANTA BARBARA
NEEDLES
HAVASU LAKE
LAVERNE
LAKE ARROWHEAD
LOS ANGELES
SAMPLING STATIONS
0 20 40 60 MILES
SCALE
SAN DIEGO
EL CENTRO

Figure 1. California surface water sampling stations

being phased out and treated water sampling being substituted or continued. This procedural change is predicated upon sampling water at the point of consumption.

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[1] Data from January and April 1966 issues of Radiological Health News, State of California Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, California.

Most of the supplies sampled have as a source, raw surface waters (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible

Table 1. Gross beta activity in California domestic waters, July–December 1965

Sampling station	Quality	Concentration, pCi/liter					
		July	Aug	Sept	Oct	Nov	Dec
Alturas	Well	[a] 9	[a] 5	[a] 6	[a] 12	[a] 12	[a] 15
Antioch	Treated	NS	[a] 13	ND	[a] 2	[a] 6	[a] 8
Lake Arrowhead	Raw	NS	[a] 3	NS	[a] 15	[a] 13	NS
Berkeley	Treated	ND	[a] 1	[a] 12	ND	ND	[a] 13
Clearlake Highlands	Treated	[a] 5	ND	[a] 8	NS	ND	[a] 8
Crescent City	Well	[a] 1	ND	ND	[a] 7	ND	[a] 3
Death Valley	Treated	[a] 16	ND	[a] 2	[a] 20	[a] 21	ND
Dos Palos	Treated	[a] 7	[a] 10	[a] 11	ND	[a] 8	ND
El Centro	Treated	[a] 1	ND	[a] 6	ND	[a] 6	[a] 19
Eureka	Raw	[a] 15	ND	ND	[a] 2	ND	[a] 12
	Treated	[a] 7	ND	[a] 3	ND	[a] 14	[a] 12
Fort Bragg	Treated	ND	NS	NS	NS	[a] 12	[a] 2
Los Angeles Laboratory	Treated	[a] 24	ND	[a] 12	ND	[a] 4	NS
Marin Municipal Water District	Treated	ND	ND	[a] 7	ND	ND	ND
Mariposa	Raw	ND	ND	[a] 17	NS	[a] 8	[a] 13
Metropolitan Water District of Southern California:							
Lake Havasu	Raw	NS	[a] 2	ND	NS	[a] 21	[a] 14
Weymouth Plant	Treated	[a] 19	ND	[a] 6	[a] 7	[a] 18	31
Lake Millerton	Raw	[a] 5	[a] 13	[a] 1	ND	[a] 10	[a] 13
Monterey	Treated	[a] 1	ND	[a] 17	ND	NS	NS
Napa	Raw	ND	NS	NS	NS	[a] 2	[a] 4
Needles	Well	[a] 11	ND	[a] 2	[a] 30	[a] 5	[a] 4
North Marin Water District	Treated	[a] 21	[a] 10	[a] 9	[a] 14	[a] 11	[a] 6
	Raw	[a] 14	[a] 17	ND	[a] 8	ND	[a] 13
	Sludge [b]	[a] 41	ND	[a] 13	[a] 7	ND	[a] 29
Oroville:							
California Water Service	Treated	[a] 5	[a] 7	ND	[a] 3	[a] 1	[a] 7
Wyandotte Irrigation District	Treated	ND	ND	ND	[a] 11	ND	[a] 7
Pleasanton	Well	NS	NS	ND	ND	ND	ND
Redding	Treated	NS	NS	NS	NS	NS	NS
Sacramento	Treated	96	17	[a] 23	[a] 3	ND	NS
Salinas	Well	NS	ND	NS	NS	ND	NS
San Diego	Raw	[a] 16	[a] 3	ND	ND	ND	[a] 19
	Treated	[a] 6	ND	ND	[a] 19	[a] 16	[a] 3
San Francisco:							
Water Department	Raw	[a] 4	ND	ND	[a] 6	[a] 7	[a] 2
Alameda, East	Raw	[a] 5	[a] 6	19	[a] 10	[a] 12	NS
Brightside Weir	Raw	ND	[a] 2	[a] 4	ND	NS	NS
Calaveras Reservoir	Raw	ND	ND	ND	ND	[a] 3	NS
Crystal Springs	Raw	ND	[a] 5	ND	ND	[a] 1	NS
Hetch Hetchy	Raw	24	[a] 17	[a] 19	[a] 4	ND	NS
San Jose	Raw	ND	ND	NS	NS	NS	NS
	Treated	NS	NS	NS	ND	ND	[a] 4
San Luis Obispo	Treated	NS	NS	[a] 8	ND	NS	ND
Santa Barbara	Treated	[a] 18	[a] 4	[a] 8	ND	[a] 13	ND
Santa Cruz	Raw	NS	ND	NS	NS	NS	NS
	Treated	ND	NS	NS	[a] 12	[a] 1	NS
Santa Rosa	Well	ND	ND	ND	[a] 5	[a] 3	[a] 5
Scotia	Treated	NS	NS	NS	NS	[a] 2	NS
Tahoe City	Raw	NS	[a] 9	NS	NS	NS	[a] 19
Ukiah	Well	[a] 6	[a] 8	[a] 1	ND	[a] 4	NS
Vallejo:							
Fleming Hill	Raw	[a] 2	[a] 4	ND	ND	[a] 9	[a] 3
	Treated	[a] 4	[a] 5	35	ND	ND	ND
Swanzy Reservoir	Treated	ND	[a] 11	ND	ND	[a] 15	[a] 2
Willits	Treated	[a] 7	ND	ND	[a] 6	[a] 2	[a] 9
Yosemite	Treated	[a] 8	[a] 5	NS	NS	[a] 10	NS
Maximum		96	17	35	30	21	31
Minimum		1	1	1	2	1	2

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best estimate, but is not statistically significant.

[b] Sludge reported in pCi/g (dry weight).

NS, no sample collected.

ND, no detectable activity.

Table 2. Radionuclide concentrations in California surface water 1962–1965

Sampling station and date	Concentration, pCi/liter						
	Potassium-40	Manganese-54	Zirconium-niobium-95	Cesium-137	Cerium-141-cerium-144	Strontium-89	Strontium-90
Antioch							
December 1963–May 1964	2.6	0.6	ND	0.2	ND	•0.9	2.4
July–December 1964	•1.4	•0.2	ND	0.8	0.0	0.0	0.3
January–July 1965	•1.6	•0.1	•0.1	•0.1	0.0	NA	1.0
Berkeley							
July–December 1963	2.6	ND	0.3	0.3	ND	48.0	1.1
January–June 1964	5.2	0.9	2.8	0.5	0.6	•2.0	1.5
July–December 1964	13.0	0.0	0.0	1.0	ND	NA	1.1
January–June 1965	•0.6	•0.2	ND	0.3	•0.2	NA	0.9
Chula Vista							
February–July 1963	•2.7	2.2	ND	0.5	ND	•14.6	0.7
August 1963–January 1964	6.4	0.6	•0.4	0.5	0.5	•0.2	1.7
Clear Lake							
June–December 1963	3.7	ND	25.2	ND	0.6	•0.7	2.7
Crescent City							
June–December 1963	3.0	0.4	•0.6	0.2	0.3	ND	0.1
July–December 1964	•0.5	ND	ND	•0.1	•0.2	0.0	0.2
Dos Palos							
July 1963–January 1964	2.3	ND	4.2	1.0	ND	4.5	0.9
May–August 1964	•0.3	•0.2	ND	•0.1	0.4	0.0	0.4
October 1964–January 1965	•3.3	•0.5	•0.1	•0.3	•0.7	NA	0.6
May–September 1965	•1.4	•0.1	ND	0.2	ND	NA	NA
El Centro							
May–October 1962	ND	ND	ND	ND	ND	ND	2.6
November 1962–April 1963	3.8	0.7	ND	•0.1	10.7	ND	•0.5
May–July 1963	•1.2	3.5	ND	3.3	3.6	ND	0.6
September 1963–March 1964	4.9	1.1	ND	1.0	0.3	NA	1.3
April–October 1964	12.0	3.1	ND	0.8	83.0	NA	1.4
November 1964–May 1965	•1.4	•0.4	ND	0.4	•0.6	NA	1.7
Eureka							
January–June 1963	3.4	•0.2	•0.9	0.2	0.4	NA	0.1
July–December 1963	ND	ND	•7.4	ND	ND	ND	0.3
January–June 1964	22.5	16.6	53.3	17.7	46.9	6.2	7.8
July–December 1964	•1.0	ND	ND	1.6	ND	NA	0.2
Marin Municipal Water District							
June–October 1963	•3.3	1.0	•2.4	ND	5.3	ND	1.2
November 1963–March 1964	3.8	•0.1	1.5	ND	0.3	•1.0	0.9
March–August 1964	5.3	•0.4	ND	•0.4	3.0	0.0	0.9
Metropolitan Water District of Southern California							
Lake Matthews							
July–December 1963	ND	0.6	2.2	0.2	1.5	•0.5	1.1
Weymouth Plant							
January–June 1964	•1.0	ND	ND	ND	0.3	ND	0.4
July–December 1964	ND	ND	ND	NA	ND	0.0	1.8
Millerton Lake							
July–December 1963	NA	NA	NA	NA	NA	•0.8	0.9
January–June 1964	•0.5	ND	ND	0.6	ND	0.0	1.0
July–December 1964	•1.2	•0.1	ND	0.4	ND	0.0	1.3
Monterey							
July 1963–January 1964	•1.8	0.6	ND	•0.1	ND	ND	0.3
January–June 1964	2.1	ND	•0.3	0.2	0.4	0.0	0.3
July–December 1964	•1.6	0.0	ND	ND	0.0	0.0	0.3
January–June 1965	5.2	•0.4	•0.4	•0.1	•0.4	NA	0.5
Napa							
October 1963–March 1964	4.8	ND	5.9	NA	0.3	NA	1.0
April–December 1964	•1.4	ND	ND	0.9	0.1	0.0	1.1
January–June 1965	•2.1	•0.2	ND	NA	0.7	NA	NA
North Marin Water District							
July–December 1963	3.3	ND	4.2	1.3	ND	ND	3.5
January–June 1964	3.8	ND	ND	0.2	•0.1	0.6	0.6
July–December 1964	5.0	•0.1	ND	•0.1	ND	0.0	2.5
January–June 1965	4.1	•0.2	ND	•0.1	•0.3	NA	1.3
Oroville							
California Water Service							
November 1964–March 1965	•0.4	•0.1	ND	0.2	ND	NA	NA
April–September 1965	•0.6	•0.1	ND	•0.1	•0.1	NA	NA
Wyandotte Irrigation District							
November 1964–March 1965	•0.2	•0.1	0.1	ND	ND	NA	1.0
April–September 1965	•0.9	•0.1	ND	0.2	ND	NA	NA
Redding							
July–December 1963	ND	0.6	2.0	0.5	1.9	ND	0.9
January–June 1964	ND	ND	1.0	0.2	2.0	•0.9	0.5
July–December 1964	•3.4	•0.7	1.0	1.0	0.1	0.8	0.8
January–June 1965	•0.9	•0.1	ND	•0.1	ND	NA	NA

See footnotes at end of table.

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Table 2. Radionuclide concentrations in California surface water 1962–1965—Continued

Sampling station and date	Concentration, pCi/liter						
	Potassium-40	Manganese-54	Zirconium-niobium-95	Cesium-137	Cerium-141-cerium-144	Strontium-89	Strontium-90
Sacramento							
July–December 1963	2.7	ND	3.1	[a] 0.2	0.7	NA	1.7
January–June 1964	[a] 0.7	ND	ND	ND	0.4	0.0	2.9
July–December 1964	[a] 1.0	[a] 0.1	ND	[a] 0.3	ND	0.0	0.8
January–October 1965	[a] 1.6	ND	ND	[a] 0.2	[a] 0.2	NA	NA
San Diego							
May–November 1963	3.5	ND	0.4	0.8	2.4	[a] 9.7	4.1
November 1963–June 1964	56.8	8.8	NA	12.7	NA	ND	4.8
July–December 1964	3.8	ND	ND	0.3	[a] 0.1	0.0	1.1
January–June 1965	4.5	[a] 0.2	ND	0.6	0.4	NA	0.3
San Francisco							
August 1963–February 1964	ND	0.5	2.4	0.2	0.7	7.5	1.1
February–October 1964	88.8	14.4	1.5	8.9	ND	0.0	1.5
San Jose							
January–June 1964	[a] 0.8	[a] 0.1	ND	[a] 0.1	ND	[a] 0.2	0.2
July–December 1964	[a] 1.0	ND	1.2	1.4	ND	0.0	0.5
January–June 1965	[a] 1.1	ND	ND	[a] 0.1	ND	NA	0.3
Santa Barbara							
December 1962–June 1963	6.3	ND	23.4	0.4	9.7	[a] 24.7	2.9
August 1963–February 1964	[a] 0.3	0.3	5.7	ND	1.5	NA	2.6
March–December 1964	ND	5.8	3.5	10.5	NA	NA	9.8
October 1964–February 1965	ND	ND	ND	ND	ND	NA	1.1
March–July 1965	3.5	[a] 0.1	ND	[a] 0.3	0.7	NA	1.0
Santa Cruz							
January–July 1963	ND	ND	[a] 0.6	ND	[a] 0.5	ND	0.6
January–May 1964	3.8	[a] 0.5	[a] 3.6	ND	4.4	[a] 1.3	3.1
May–November 1964	12.0	NA	NA	2.3	3.4	0.0	0.4
Santa Rosa							
July–December 1963	ND	0.5	2.4	ND	1.4	[a] 0.4	0.2
January–June 1964	[a] 0.5	0.4	ND	0.6	ND	ND	0.2
July–December 1964	[a] 1.4	[a] 0.3	[a] 0.5	[a] 0.1	0.0	0.0	0.1
January–June 1965	[a] 0.2	[a] 0.1	ND	ND	0.5	NA	0.2
Scotia							
July–December 1964	3.5	2.2	5.8	1.5	1.6	0.0	0.5
Tahoe City							
June–December 1964	ND	ND	ND	0.1	ND	0.0	0.3
January–June 1965	[a] 1.5	ND	[a] 0.4	0.3	ND	NA	0.3
Ukiah							
January–June 1964	7.8	ND	15.9	ND	1.6	0.0	0.4
Vallejo							
January–June 1965	[a] 1.7	[a] 0.2	ND	[a] 0.1	[a] 0.1	NA	1.2
Willits							
December 1963	7.5	0.9	5.0	0.3	2.2	[a] 2.1	0.6
Yosemite							
July 1963–January 1964	4.5	1.4	12.5	0.4	1.4	11.5	1.5
January–December 1964	[a] 0.8	ND	ND	[a] 0.5	0.7	0.0	1.1
January–June 1965	[a] 0.5	[a] 0.2	[a] 0.4	0.4	ND	NA	1.2

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error the value reported is the best available estimate, but is not statistically significant.

ND, no detectable activity.

NA, no analysis reported.

to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or surface streams. Under the present sampling schedule, monthly 500-ml samples are collected and the total solids analyzed for alpha and beta radioactivity. In addition, 3-liter samples are collected monthly for approximately 6 months and composited for specific radionuclide analysis on a semiannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Laboratory. Measurements of alpha and alpha-plus-beta activities are made with a low-background, windowless gas-flow proportional counter. Counting methods used follow those recommended by the U.S. Public Health Service (*1*).

Individual samples are evaporated to dryness and the residue ashed at 450°C. The ashed sample is dissolved and transferred to an aluminum planchet for beta counting. Gamma-emitting radionuclides are determined annually on the composite samples.

Discussion

Table 1 shows the monthly average beta activity in the suspended-plus-dissolved solids in surface water supplies in California from July through December 1965. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has, in general, been undetectable or very slight, alpha activity analyses are not presented. No increase in radioactivity level of surface water has been observed. Table 2 shows specific radionuclide concentrations in California surface waters semiannually by stations from 1962 to 1965. Data for 1960 to 1963 were published in the March 1965 issue of *Radiological Health Data*.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59-6. Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 16, 1959).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
1961–June 1962	April 1963
July–December 1962	September 1963
January–June 1963	March 1964
July–December 1963	September 1964
January–June 1964	March 1965
July–December 1964	September 1965
January–June 1965	March 1966

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Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to the programs presented in this issue, the following program was previously covered in *Radiological Health Data and Reports:*

Program	Period reported	Last presented
HASL Fallout Network	July–December 1965	September 1966

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1. Radiation Surveillance Network
July 1966

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN), Division of Radiological Health, Public Health Service, which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators report (by telephone) field estimates greater than 10 pCi/m^3 (except for Hawaii, Alaska, and Puerto Rico, which report estimates greater than 5 pCi/m^3) to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. Field estimates and laboratory measurements of daily concentrations and the estimated ages for selected samples are reported in the monthly RSN report (*2*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

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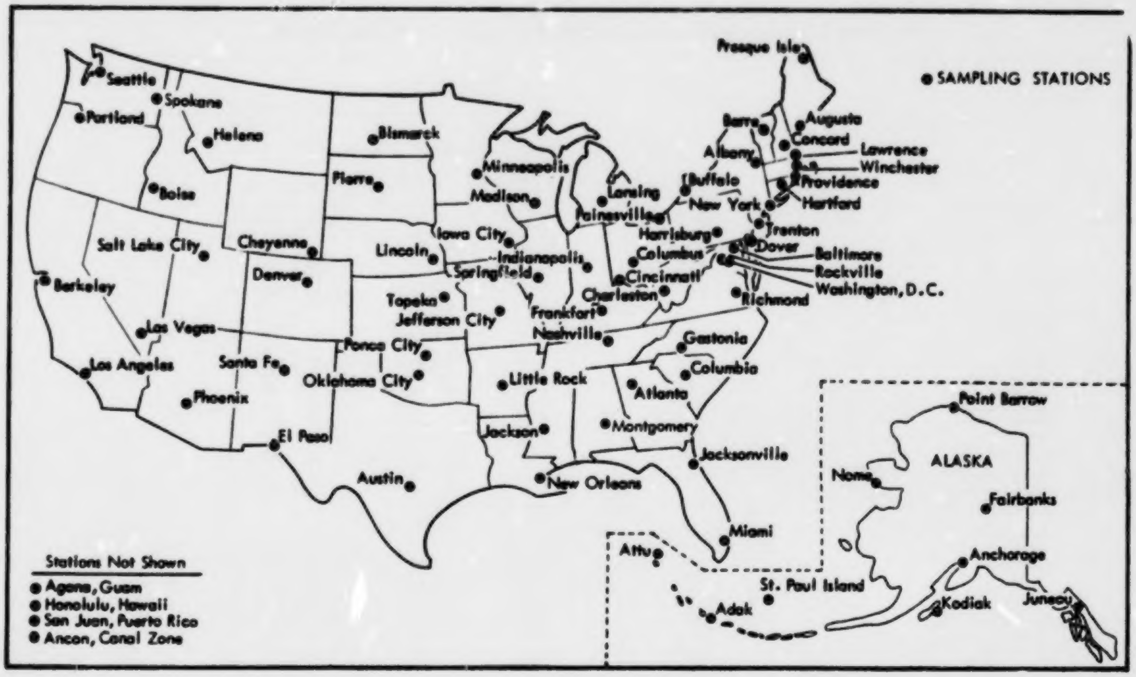
● SAMPLING STATIONS
Presque Isle
Seattle
Spokane
Portland
Helena
Bismarck
Minneapolis
Madison
Pierre
Boise
Lansing
Buffalo
Barre
Augusta
Concord
Lawrence
Winchester
Albany
Providence
Hartford
New York
Painesville
Harrisburg
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Columbus
Cincinnati
Charleston
Richmond
Iowa City
Salt Lake City
Cheyenne
Lincoln
Indianapolis
Springfield
Denver
Berkeley
Topeka
Jefferson City
Frankfort
Las Vegas
Nashville
Ponca City
Gastonia
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Columbia
Atlanta
Phoenix
Point Barrow
El Paso
Jackson
Montgomery
ALASKA
Jacksonville
Nome
Austin
New Orleans
Fairbanks
Miami
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

Sampling and analytical procedures

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. About 1,800 cubic meters of air are drawn through a filter during the 24-hour sampling period. The filters are forwarded to the RSN laboratory in Rockville, Maryland, where the gross beta activity is measured 4 days after the sampling period and again 7 days later if the net count rate is 2,000 cpm (approximately 1 pCi/m³). By using the two counts and the Way-Wigner formula (*3*), the age of fission products is estimated and the activity at time of collection determined.[1] Additionally, analyses for specific radionuclides may be performed.

The total precipitation is sampled continuously at most RSN stations on a daily basis, using funnels with collection area of 0.4 square meter. If the rainfall exceeds 0.2 inch, the precipitation sample is analyzed for gross beta activity (*2*). Additionally, analyses for specific radionuclides may be performed.

In the laboratory the gross beta activity in evaporated precipitation samples is calculated by the same method used for analyzing the air filters. Total deposition (D) is determined by the equation:

$$D(\mathrm{nCi/m^2}) = \frac{\text{concen (pCi/liter} \times \text{pptn depth (mm)}}{1{,}000}$$

Selected air and precipitation samples are analyzed by gamma spectrometry to determine the presence of fresh fission products. The methods discussed by Burrus (*4*) and Covell (*5*) were adapted for resolving the complex gamma spectra.

Monthly values of gross beta activity in air, total deposition, and depth of precipitation are given in table 1 for July 1966. Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 305 air samples. No fresh fission products were positively identified on air samples during July 1966.

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[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently, the calculated age of the fresh component will be overestimated.

Table 1. Gross beta activity in surface air and precipitation, July 1966

Station location		Number of samples		Air surveillance (gross beta activity, pCi/m³)			Last profile in *RHD & R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	31	4	0.30	<0.10	<0.14	Nov 66	50	<10
Alaska:	Adak	31		<0.10	<0.10	<0.10	June 66	(c)	
	Anchorage	18	6	0.26	<0.10	<0.14	Mar 66	16	<3
	Attu Island	22		<0.10	<0.10	<0.10	July 66	(c)	
	Fairbanks	16	2	<0.10	<0.10	<0.10	Apr 66	9	<2
	Juneau	19	8	0.12	<0.10	<0.10	July 65	86	<17
	Kodiak	16		<0.10	<0.10	<0.10	May 66	(c)	
	Nome	7		0.12	<0.10	<0.10	Sept 66	(c)	
	Pt. Barrow	27		<0.10	<0.10	<0.10	Aug 66	(c)	
	St. Paul Island	30		<0.10	<0.10	<0.10	Oct 66	(c)	
Ariz:	Phoenix	27		0.35	<0.10	<0.17	July 65	(c)	
Ark:	Little Rock	20	4	0.22	<0.10	<0.12	Mar 66	98	<20
Calif:	Berkeley	30		<0.10	<0.10	<0.10	May 66	(c)	
	Los Angeles	20		0.20	<0.10	<0.12	Sept 66	(c)	
C.Z:	Ancón	16		<0.10	<0.10	<0.10	May 66	(c)	
Colo:	Denver	30	6	0.32	<0.10	<0.14	May 66	18	<4
Conn:	Hartford	31	6	0.25	<0.10	<0.15	Apr 66	56	<11
Del:	Dover	20		0.23	<0.10	<0.17	Nov 66	(c)	
D.C:	Washington	23	4	0.28	<0.10	<0.16	Aug 66	12	<2
Fla:	Jacksonville	30	10	0.18	<0.10	<0.11	Mar 66	148	<30
	Miami	30	11	0.24	<0.10	<0.12	Apr 66	176	<35
Ga:	Atlanta	(b)	7				Oct 66	100	<20
Guam:	Agana	28		0.13	<0.10	<0.10	Feb 66	(c)	
Hawaii:	Honolulu	31	1	0.13	<0.10	<0.10	July 66	10	<2
Idaho:	Boise	29		0.29	<0.10	0.17	July 66	(c)	
Ill:	Springfield	30	2	0.29	<0.10	<0.16	Aug 66	18	<4
Ind:	Indianapolis	31	8	0.30	<0.10	<0.18	Oct 66	56	<11
Iowa:	Iowa City	30	4	0.35	<0.10	<0.17	May 66	104	<21
Kans:	Topeka	31	3	0.32	<0.10	<0.14	Mar 66	19	<4
Ky:	Frankfort	27	5	0.33	<0.10	<0.17	Aug 66	29	<6
La:	New Orleans	31	13	0.26	<0.10	<0.13	Aug 66	243	<49
Maine:	Augusta	31	9	0.27	<0.10	<0.16	Sept 66	47	<9
	Presque Isle	24	6	0.20	<0.10	<0.13	May 66	62	<13
Md:	Baltimore	19	2	0.30	<0.10	<0.19	Apr 66	16	<3
	Rockville	17		0.23	<0.10	0.17	July 66	(c)	
Mass:	Lawrence	31	7	0.33	<0.10	<0.20	Nov 66	79	<16
	Winchester	28	8	0.23	<0.10	<0.14	June 66	65	<13
Mich:	Lansing	31	6	0.26	<0.10	<0.15	July 66	37	<7
Minn:	Minneapolis	19	4	0.20	<0.10	<0.14	Feb 66	73	<15
Miss:	Jackson	30	4	0.37	<0.10	<0.13	Sept 66	63	<13
Mo:	Jefferson City	31	6	0.29	<0.10	<0.14	Oct 66	59	<12
Mont:	Helena	31	2	0.29	<0.10	0.20	June 66	8	<2
Nebr:	Lincoln	20	2	1.74	<0.10	<0.21	Oct 66	20	<4
Nev:	Las Vegas	25		0.33	<0.10	<0.18	Apr 66	(c)	
N.H:	Concord	20		0.26	<0.10	0.20	Aug 66	(c)	
N.J:	Trenton	30	2	0.26	<0.10	<0.17	Sept 66	6	<1
N.M:	Santa Fe	29	7	0.25	<0.10	<0.13	June 66	36	<7
N.Y:	Albany	19	4	0.43	<0.10	<0.17	Oct 66	57	<12
	Buffalo	30		0.23	<0.10	<0.15	May 66	(c)	
	New York	30		0.30	<0.10	<0.14	June 66	(c)	
N.C:	Gastonia	31	6	0.27	<0.10	<0.16	May 66	43	<9
N. Dak:	Bismarck	29	6	0.36	<0.10	<0.16	Aug 66	54	<11
Ohio:	Cincinnati	20		0.18	<0.10	<0.11	Nov 66	(c)	
	Columbus	31	9	0.51	<0.10	0.29	Sept 66	119	<24
	Painesville	31	3	0.30	<0.10	0.18	Apr 66	16	<3
Okla:	Oklahoma City	29	2	0.26	<0.10	<0.12	July 66	4	<1
	Ponca City	25	6	0.17	<0.10	<0.11	Apr 66	81	<16
Ore:	Portland	31	6	0.19	<0.10	<0.12	Oct 66	21	<4
Pa:	Harrisburg	31	2	0.24	<0.10	<0.12	Oct 66	8	<2
P.R:	San Juan	26	5	0.42	<0.10	<0.15	Sept 66	109	<22
R.I:	Providence	28	8	0.25	<0.10	<0.14	July 66	70	<14
S.C:	Columbia	27	6	0.27	<0.10	<0.13	June 66	101	<20
S. Dak:	Pierre	31	3	0.36	<0.10	<0.16	July 65	66	<13
Tenn:	Nashville	31	5	0.25	<0.10	<0.13	July 66	81	<16
Tex:	Austin	31	2	0.66	<0.10	<0.16	Nov 66	7	<1
	El Paso	31	4	0.27	<0.10	<0.13	Aug 66	15	<3
Utah:	Salt Lake City	31	5	0.34	<0.10	<0.17	Sept 66	7	<2
Vt:	Barre	29	8	0.27	<0.10	<0.16	Mar 66	56	<11
Va:	Richmond	31	6	0.23	<0.10	<0.14	Mar 66	129	<26
Wash:	Seattle	29	6	<0.10	<0.10	<0.10	Mar 66	29	<6
	Spokane	31		0.30	<0.10	<0.15	Feb 66	(c)	
W. Va:	Charleston	28	9	0.26	<0.10	<0.15	June 66	105	<21
Wis:	Madison	29	6	0.21	<0.10	<0.13	Mar 66	107	<22
Wyo:	Cheyenne	30	5	0.29	<0.10	<0.14	Apr 66	66	<16
Network summary		1,958	291	1.74	<0.10	<0.14		59	<12

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[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If more than 10 percent of the samples contain <0.10 pCi/m³, a less-than sign is placed before the average.

[b] No report received.

[c] No precipitation sample collected.

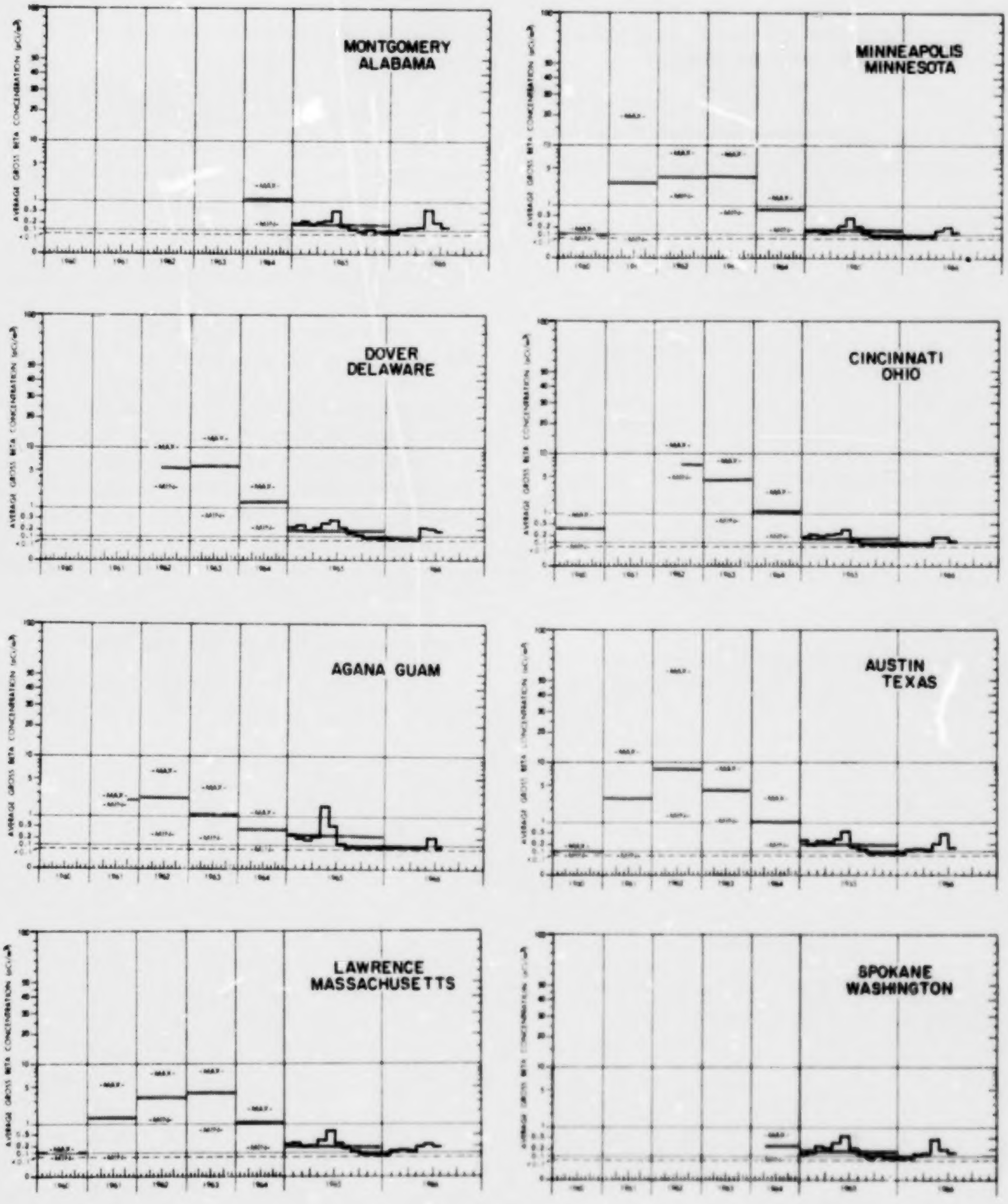

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1960–July 1966

2. Canadian Air and Precipitation Monitoring Program July 1966[2]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations (figure 3) are located at airports, where the sampling equipment is operated by personnel from the Meteorologic Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*6–10*).

Air sampling procedure and results

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch diameter glass-fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa for analysis.

To determine the beta activity, a 2-inch diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system calibrated with a strontium-yttrium-90 standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for July 1966 are presented in table 2.

Precipitation collection and analysis

The amount of radioactive fallout deposited on the ground is determined from measure-

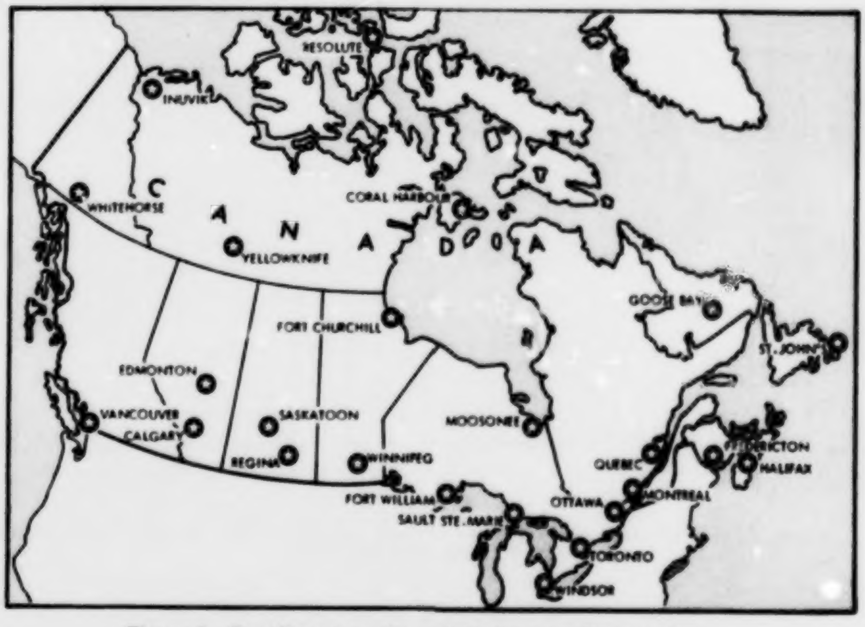
RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
MONTREAL
FORT WILLIAM
OTTAWA
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

ments on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is 1 month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

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[2] Prepared from August 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are added to selected samples depending upon the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter together with the polyethylene liner is then ignited and ashed at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infrared lamp, and then counted with a thin-end window Geiger-Mueller counter calibrated with a strontium-yttrium-90 source.

The monthly precipitation samples represent the total deposition of radioactive materials on the earth's surface. The July 1966 gross beta deposition values are given in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, July 1966

Station	Number of samples	Air surveillance activity, pCi/m³			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.4	0.0	0.2	54	6.1
Coral Harbour	31	0.3	0.0	0.1	NS	NS
Edmonton	31	0.3	0.0	0.1	77	7.7
Ft. Churchill	31	0.2	0.0	0.1	95	0.7
Ft. William	31	0.2	0.0	0.1	23	1.0
Fredericton	31	0.2	0.0	0.1	59	4.3
Goose Bay	13	0.2	0.0	0.1	13	2.7
Halifax	31	0.2	0.0	0.1	64	2.9
Inuvik	31	0.3	0.0	0.1	46	1.2
Montreal	14	0.3	0.1	0.2	50	4.2
Moosonee	31	0.3	0.1	0.2	NS	NS
Ottawa	31	0.3	0.0	0.2	52	4.1
Quebec	30	0.2	0.1	0.1	48	3.3
Regina	31	0.4	0.0	0.2	119	3.4
Resolute	31	0.1	0.0	0.0	94	1.4
St. John's, Nfld	30	0.2	0.0	0.1	24	2.0
Saskatoon	30	0.3	0.0	0.2	95	4.6
Sault Ste. Marie	29	0.3	0.0	0.2	97	3.2
Toronto	31	0.4	0.1	0.2	100	1.9
Vancouver	31	0.2	0.0	0.1	45	2.9
Whitehorse	[illegible]	0.2	0.0	0.1	79	2.5
Windsor	[illegible]	0.4	0.1	0.2	34	3.4
Winnipeg	[illegible]	0.4	0.0	0.2	40	3.4
Yellowknife	31	0.2	0.0	0.1	79	1.2
Network summary	—	0.4	0.0	0.1	64	3.1

NS, no sample.

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3. Mexican Air Monitoring Program May and June 1966

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energia Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F., Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de Mexico, the Chemistry Department of the University of Mérida, the Institute de Zonas Déserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day, using high-volume samplers.

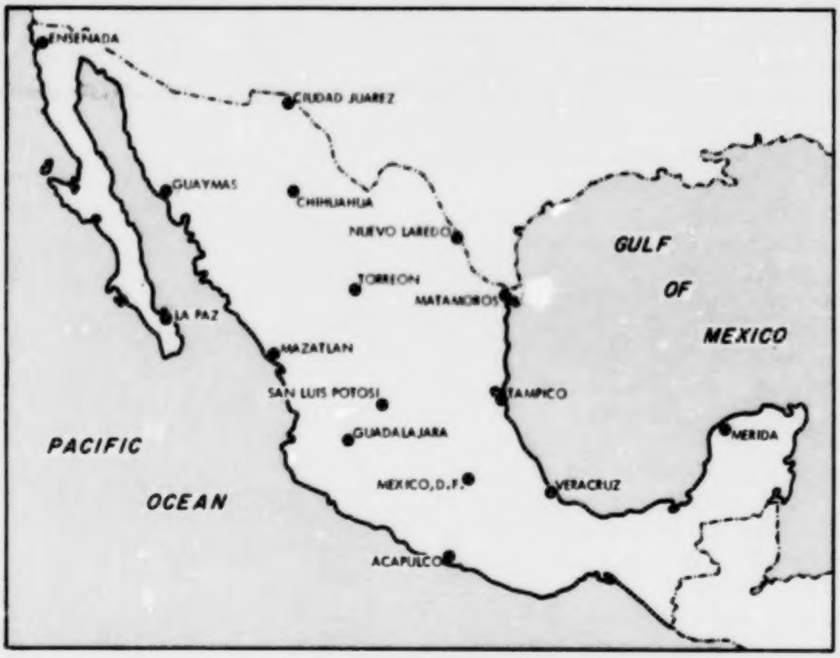
ENSENADA
CIUDAD JUAREZ
GUAYMAS
CHIHUAHUA
NUEVO LAREDO
TORREON
MATAMOROS
GULF
OF
MEXICO
LA PAZ
MAZATLAN
SAN LUIS POTOSI
TAMPICO
MERIDA
GUADALAJARA
PACIFIC
OCEAN
MEXICO, D.F.
VERACRUZ
ACAPULCO

Figure 4. Fallout network sampling stations in Mexico

After each 20-hour sampling period, the filter is removed and shipped via air mail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta activity, allowing a minimum of 3 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a mimimum of eight samples per month were needed to get a reliable average activity at each station (*11*).

The maximum, minimum, and average fission product beta concentrations in surface air during May and June 1966 are presented in tables 3 and 4.

Table 3. Mexican gross beta activity of airborne particulates, May 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	11	3.7	<0.1	1.0
Ciudad Juarez	15	2.6	0.1	0.5
Ensenada	3	0.3	0.2	0.2
Guadalajara	10	0.6	0.1	0.2
Guaymas	9	0.5	<0.1	0.3
La Paz	4	0.2	0.1	0.1
Matamoros	NS			
Mazatlán	NS			
Mérida	9	1.5	0.1	0.8
México, D.F.	6	0.2	0.1	0.1
Nuevo Laredo	9	0.6	0.1	0.2
San Luis Potosí	14	3.6	<0.1	0.6
Tampico	8	1.2	<0.1	0.4
Torreón	15	2.2	0.1	0.5
Veracruz	8	1.1	0.1	0.5

NS, no sample collected: station temporarily shut down.

Table 4. Mexican gross beta activity of airborne particulates, June 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	8	7.3	0.3	3.0
Ciudad Juarez	15	1.1	0.2	0.6
Ensenada	NS			
Guadalajara	NS			
Guaymas	5	1.3	0.3	0.6
La Paz	11	0.8	0.2	0.4
Matamoros	NS			
Mazatlán	15	3.2	0.3	0.9
Mérida	12	0.9	0.1	0.5
México, D.F.	9	1.3	0.1	0.5
Nuevo Laredo	9	1.6	0.2	0.6
San Luis Potosí	NS			
Tampico	12	1.9	0.3	0.8
Torreón	15	3.8	0.1	0.7
Veracruz	16	1.0	0.1	0.4

NS, no sample collected: station temporarily shut down.

4. Pan American Air Sampling Program July 1966

Pan American Health Organization and *U.S. Public Health Service*

Gross beta activity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO), and the U.S. Public Health Service (PHS) to assist PAHO member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station locations are shown in figure 5.

Table 5. PAHO gross beta activity in surface air, July 1966

Station location	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average *
Argentina: Buenos Aires	19	6.71	<0.10	<0.38
Chile: Santiago	30	46.56	<0.10	<3.74
Colombia: Bogota	18	<0.10	<0.10	<0.10
Ecuador: Guayaquil	30	13.72	<0.10	<1.69
Jamaica: Kingston	25	0.17	<0.10	<0.11
Peru: Lima	20	72.04	<0.10	<9.44
Venezuela: Caracas	15	<0.10	<0.10	<0.10
West Indies: Trinidad	19	<0.10	<0.10	<0.10
Pan American summary	176	72.04	<0.10	<1.95

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more of the samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.

The July 1966 air monitoring results from the participating countries are given in table 5. Fresh fission products, presumably from the

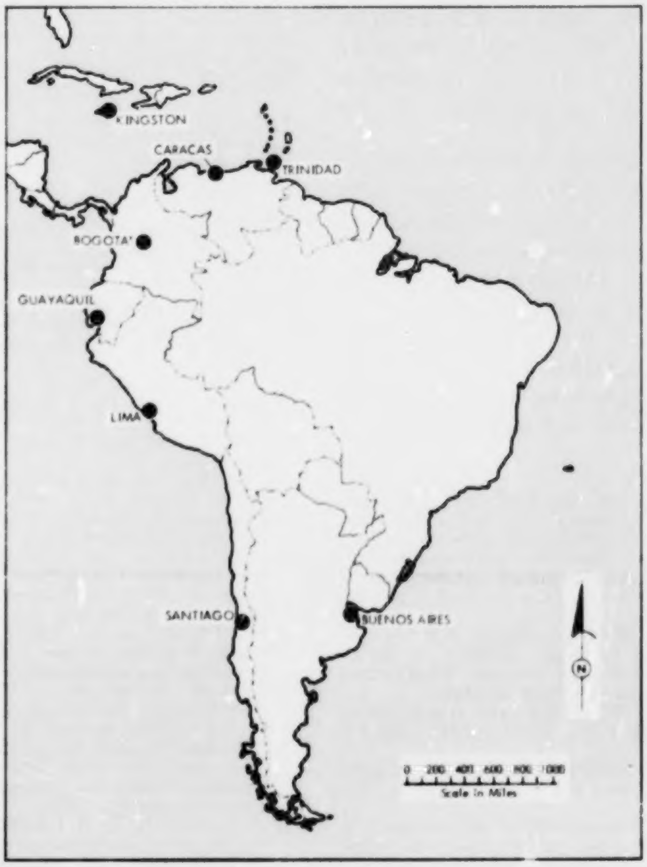

Figure 5. Pan American Air Sampling Program stations

French test on July 2, 1966, were identified as shown in table 6.

Table 6. Occurrence of fresh fission products in PAHO samples

Station	Inclusive date	Peak gross beta activity, pCi/m³ (at time of collection)
Lima, Peru	July 12-20, 1966	72.04
Santiago, Chile	July 7-11, 1966	46.56
Buenos Aires, Argentina	July 9-13, 1966	6.71
Guayaquil, Ecuador	July 14-22, 1966	1[illegible].72

The activities observed on these PAHO air samples were comparable to those observed at the various U.S. stations during Chinese testing.

A slight increase in activity was also noted during the last week of July 1966 at Santiago, Chile. Gamma analysis of the July 30, 1966, Santiago sample and a sample from Lima, Peru, for August 1, 1966, showed small quantities of fresh fission products.

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5. Plutonium in Airborne Particulates April–June 1966

Division of Radiological Health
Public Health Service

The Radiation Surveillance Network (RSN) of the Division of Radiological Health, Public Health Service, located at Rockville, Maryland, is continuing routine analysis for plutonium in air particulates. These analyses were initiated during 1965 as part of the mission to establish, maintain, and operate a national surveillance network to measure radioactivity in the environment.

Air filters from eleven RSN stations are analyzed monthly for plutonium. Each daily filter is counted for gross beta activity and for gamma emitters by gamma spectrometry 4 to 5 days after collection. For plutonium analysis, a monthly composite is made of one-half of each individual sample for each station. Each composite representing 10,000 to 20,000 cubic meters of air is analyzed by gamma spectrometry prior to the plutonium analysis.

Data for the months of November 1965 through March 1966, with details of the method of collection and radiochemical analysis, were presented in an earlier report (*12*). Results for April to June 1966 are given in table 7.

Table 7. Plutonium in airborne particulates April–June 1966

Station location	Plutonium content, pCi/1,000 m³ ᵃ		
	April	May	June
Alaska: Anchorage	0.194	0.079	0.096
Ariz: Phoenix	0.369	0.239	0.215
Colo: Denver	0.198	0.239	0.191
Hawaii: Honolulu	0.154	0.117	0.087
La: New Orleans	0.149	0.110	0.169
Md: Rockville	0.111	0.174	0.202
N.C: Gastonia	0.159	0.159	0.208
N.Y: Buffalo	0.092	0.146	0.119
S. Dak: Pierre	0.149	0.197	0.132
Tex: Austin	0.144	0.134	0.151
Wash: Seattle	0.095	0.094	0.051

ᵃ Plutonium includes plutonium-238, plutonium-239, and plutonium-240.

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(*11*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963–1965. Comisión Nacional de Energia Nuclear. Dirección General de Seguridad Radiológica (en prensa 1966).

(*12*) RUSSELL, J., H. LEVINE, and R. SCHNEIDER. Plutonium in airborne particulates, November 1965 through March 1966. Radiol Health Data Rep 7:483–484 (August 1966).

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by the AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of environmental radioactivity data follow for the Lawrence Radiation Laboratory and the Mound Laboratory.

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[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

1. Lawrence Radiation Laboratory July–December 1965[2]

University of California
Berkeley, California

Berkeley Site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is located to the east of the University of California campus (figure 1). Winds are generally westerly; annual rainfall is 23 inches, most of which usually falls during the period from November through April. Technical facilities include a 6.3 BeV proton accelerator (Bevatron), a 700–MeV cyclotron, a 10–MeV linear accelerator, an 88-inch cyclotron, and various chemistry and physics laboratories.

The environmental sampling program includes monitoring of the atmosphere, surface

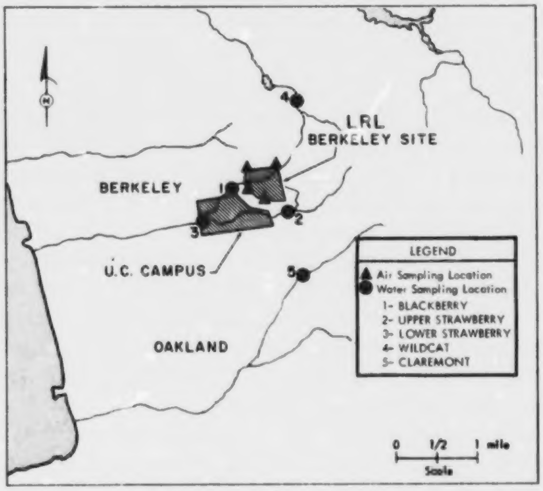

Figure 1. Environmental sampling locations at the Berkeley site

and ground waters, sewage, rain, and dry depositions. Three types of atmospheric samples are taken: stack samples, local area samples, and perimeter samples.

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[2] Summarized from "Results of Environmental Radioactivity Sampling Program," Lawrence Radiation Laboratory, second half 1965.

Approximately 110 "stacks" with potential for releasing radioactive contaminants are sampled continuously at a flow rate of 1 liter per minute. The 1-inch-diameter filters are changed weekly and counted for beta activity by an end-window Geiger-Mueller tube, and for alpha activity by a thin-window proportional counter. Local area and perimeter air samples are taken at locations on the laboratory site and at the property line, respectively. The samples are obtained on 4- by 9-inch HV–70 filter papers at 4 cubic feet per minute. The filters are changed weekly and counted for alpha activity by a thin-window proportional counter, and for beta activity by a 30-mg/cm^2 end-window Geiger-Mueller tube. A 40 percent loss in the alpha count is assumed for self absorption. The average levels of activity observed in each type of sample are given in table 1.

Table 1. Atmospheric monitoring, Berkeley site July–December 1965

Sampling locations (number of locations)	Number of samples	Average concentrations (pCi/m^3)	
		Alpha activity	Beta activity
Stacks (111)	4,612	0.008	2.0
Local area (10)	253	0.001	0.11
Perimeter (4)	102	0.001	0.12

Rain and dry deposition samples are collected monthly in 18-inch-diameter cylindrical vessels lined with polyethylene bags at local area and perimeter sites. Aqueous samples are poured into beakers and evaporated. Dry samples are obtained by rinsing the bags with dilute nitric acid and concentrating the resulting solution by evaporation. Final evaporation is conducted in 2-inch-diameter stainless-steel planchets, which are flamed and coated with a thin lacquer film. The planchets are counted for alpha activity in an internal-flow proportional counter and for beta activity with a thin-window, low-background Geiger-Mueller flow counter. No correction is made for self-absorption in the sample. Deposition data are given in table 2.

Table 2. Total deposition, Berkeley site July–December 1965

Sampling locations (number of locations)	Number of samples	Average concentrations (nCi/m^2)	
		Alpha activity	Beta activity
Local area (10)	58	0.15	2.86
Perimeter (4)	24	0.12	4.56

Water samples are taken from sewers, onsite streams, and offside streams. Two sewer lines serve the LRL area. The "Hearst" sewer receives waste from the larger part of the area. A sampling system takes a continuous proportional sample from the Hearst sewer as it leaves the laboratory boundary. Samples are also taken of waste feeding into the Hearst sewer from buildings 70, 70A, and 71. The "Strawberry" sewer receives waste from the southeast part of the laboratory site. A monitoring station takes a continuous proportional sample from this sewer. Continuous samples are also taken from the acid waste systems in building 74 which is the most likely contributor of radioactivity to this sewer line. The concentrations of radioactive wastes in sewage, shown in table 3, are either those observed directly in samples from the sewer line or those calculated from samples taken from contributing waste streams, whichever has the higher value. Strawberry and Blackberry Creeks comprise the laboratory's storm drainage. These are sampled weekly at three locations. Two other nearby offsite streams are also sampled weekly. All water samples are handled in the same manner as rain samples. The results from the water sampling program are presented in table 3.

Table 3. Water monitoring, Berkeley site July–December 1965

Type and source of sample	Number of samples	Average concentrations (pCi/liter)	
		Alpha activity	Beta activity
Sewage:			
Hearst sewer	34	0.42	34.7
Strawberry sewer	25	0.06	26.0
Tap water	24	0.03	3.0
Surface water:			
Onsite streams	77	0.80	7.8
Offsite streams	52	0.54	3.5

Livermore site

The Livermore site of LRL (figure 2) is located about 50 miles southeast of San Francisco, California. Annual precipitation in the Livermore Valley is about 14 inches; prevailing winds are from the west with frequent nocturnal inversions. Technical facilities include a small cyclotron, a 2-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

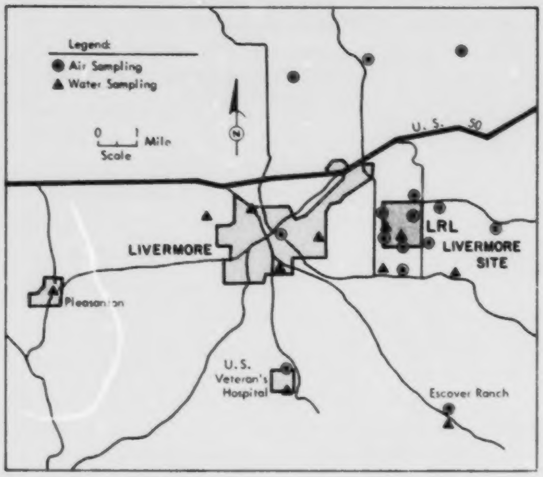

Figure 2. Environmental sampling locations at the Livermore site

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, and sewage plant products. Air samples are collected to ascertain that control efforts are restricting the release of radioactivity from the laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and is the sole supply for ranches in the Livermore and Amador Valleys.

Air samples are collected continuously at 15 sites within 5 miles of the laboratory. Samples are collected at a rate of 4 cfm on 100-square centimeter HV–70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters.

All environmental air samples are counted in an automated system which utilizes gas flow proportional detectors for both alpha and beta activities measurements. Alpha activity in 375 air samples averaged 0.0009 pCi/m^3, while beta activity averaged 0.072 pCi/m^3.

The measurement of low-level "background" radiation during the 6-month period was accomplished with fluoroglass dosimeters located at nine points on the site perimeter and at two nearby ranches. The dosimeters, which have a detection limit of 50 mR, were read after 6 months of exposure. Only one dosimeter, opposite one irradiation facility, indicated detectable external radiation amounting to an average dose rate of 0.02 mR/hr for the 6-month period. The average dose rate at the laboratory perimeter, based upon this one detectable dose, was determined to be less than 0.01 mR/hr.

Domestic water samples are collected monthly from nine nearby areas. No water sample showed an alpha concentration above the limit of sensitivity (5.0 pCi/liter) for the automatic gas flow proportional detection system. The beta activity ranged from less than the limit of sensitivity (1.8 pCi/liter) to 12.3 pCi/liter. The average beta concentration was 2.8 pCi/liter.

Samples are collected every Monday, Wednesday, and Friday at the sewer line leaving the southwest project boundary, where it connects with the Livermore domestic sewerage system. Grab samples are collected monthly at the Livermore Sewage Disposal Plant to assure that the liquid effluent from the laboratory is not creating abnormal radioactivity concentrations either in the oxidation ponds (which overflow into a natural waterway) or in the dried sludge (which is used as an agricultural soil conditioner). Radioactivity levels in the raw sewage, oxidation ponds, and dried sludge are summarized in table 4.

Table 4. Environmental sampling, Livermore July–December 1965

Type of sample	Average concentration	
	Alpha activity	Beta activity
Raw sewage, pCi/liter	5.4	61
Oxidation ponds, pCi/liter	12	70
Dried sludge, pCi/g	60	18

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha activity fluctuated from less than the limit of sensitivity (1.5 pCi/g) to 12 pCi/g. The beta activity fluctuated from less than the limit of sensitivity (3.5 pCi/g) to 25 pCi/g. The average alpha concentration was 2.0 pCi/g and the average beta concentration was 9.9 pCi/g. The concentrations are in the normal range for soil in the Livermore Valley.

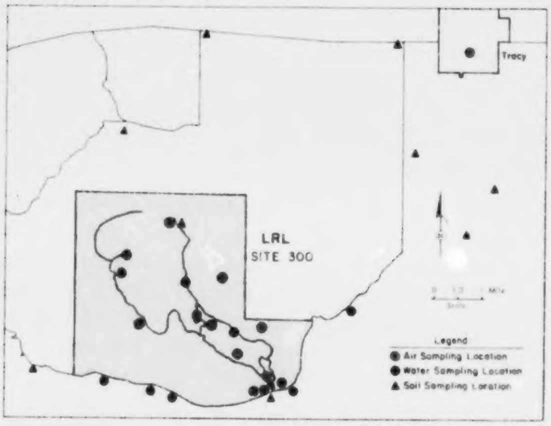

Figure 3. Sampling locations at Site 300 Lawrence Radiation Laboratory

Site 300

Site 300 (figure 3) is located in a very sparsely populated ranching area about 17 miles southeast of the Lawrence Radiation Laboratory at Livermore. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity in levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed on an irregular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power facilities offsite. Water samples are taken from six onsite wells because they are the only readily accessible sources of underground water. Samples are collected from streams only during the winter months when water flow exists. Soil samples are collected monthly at nine offsite locations. Only top layer soil is collected to determine fallout concentrations. All air, water, and soil samples are processed at the laboratory in Livermore. The average radioactivity levels in all types of samples are summarized in table 5.

Table 5. Environmental sampling, Site 300 July–December 1965

Type of sample	Average concentration	
	Alpha activity	Beta activity
Air, pCi/m³	0.0004	0.069
Water, pCi/liter	<5.0	5.3
Soil, pCi/g	4	15

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1961	October 1962
Calendar year 1962	October 1963
Calendar year 1963	October 1964
January–June 1964	May 1965
July–December 1964	November 1965
January–June 1965	May 1966

2. Mound Laboratory July–December 1965[3]

Monsanto Research Corporation Miamisburg, Ohio

During the period covered by this report, radioactive materials from Mound Laboratory did not contribute any measurable penetrating radiation, such as gamma or hard beta, to the environment. Of the radionuclides in use at Mound Laboratory, only polonium–210, plutonium–239, and hydrogen–3 (tritium) are potential environmental contaminants.

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[3] Summarized from "Environmental Monitoring Report: July–December 1965 and 1965 Summary" (MLM–1335).

The environmental monitoring program, conducted by the Monsanto Research Corporation, is planned and coordinated with regard to all of the various projects performed in the laboratory. Air and water monitoring methods and results are discussed below.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha emitters, was used in the routine monitoring of environmental air at 96 locations within a radius of 20 miles from the laboratory during the collection period. The choice of sites on a given day was dependent upon the wind direction at the time of collection.

During the 6-month period ending December 1965, 328 samples were evaluated for airborne tritium. In all cases, tritium was nondetectable.

A total of 309 air samples were collected and analyzed for possible polonium and plutonium contaminants in the environment. A long-lived gross alpha determination was made on filter paper samples after a sufficient time had elapsed to permit the decay of the short-lived daughter products of radon and thoron. The filter paper samples were counted for alpha particle emissions in a low background proportional counter. The average measured concentrations of alpha activity in air are summarized in table 6. No specific determinations of polonium-210 or plutonium-239 were made, since the gross alpha activity remained substantially below the environmental limits for these nuclides.

Table 6. Atmospheric monitoring of long-lived alpha concentrations, Mound Laboratory environs, July–December 1965

Sampling locations (number of sites)	Number of samples	Average concentration (pCi/m³)
Upwind from laboratory (16)	52	0.0014
Downwind from laboratory (95)	309	0.0025

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed in special waste disposal plants designed to reduce radioactivity to a concentration at which it may be discharged to the Great Miami River.

Helium-3, which is purified at the Mound Laboratory, contains small quantities of tritium. Liquid wastes from this operation are treated separately to assure that the radioactivity level is below the maximum permissible concentration before discharge to the Great Miami River.

Weekly water samples are collected from a drainage ditch and five locations along the Great Miami River as shown in figure 4. Additional samples are taken quarterly at more distant downstream points. The drainage ditch carries all storm sewer water and liquid tritium and treated plutonium wastes from the plant site. Sampling location number 2 (figure 4) is located at the point of discharge of the laboratory polonium waste disposal plant effluent to the Great Miami River, and number 6 at Franklin, Ohio, is 5 miles downstream from the effluent outlet.

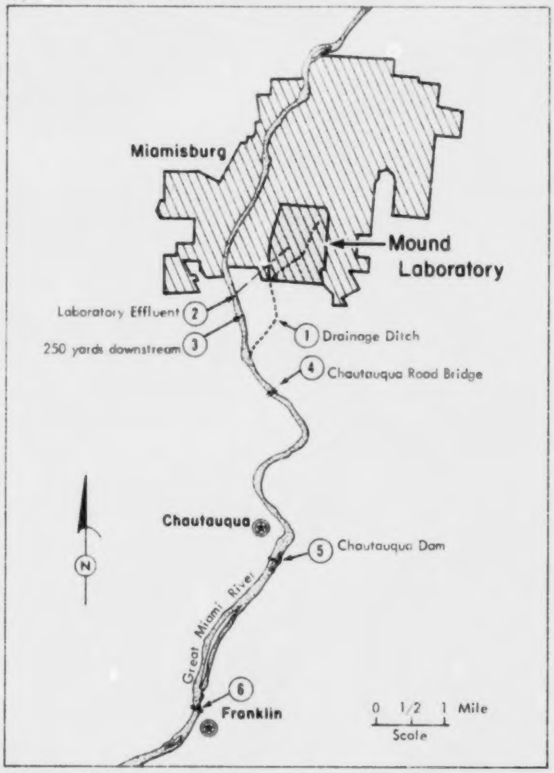

Figure 4. Water sampling locations, Mound Laboratory

All of the river samples are analyzed for polonium–210. The drainage ditch samples and some of the river samples are analyzed for hydrogen–3 (tritium). The drainage ditch samples are also analyzed for plutonium–239. Average concentrations of hydrogen–3 (tritium), polonium–210, and plutonium–239 are given in table 7 for the final 6 months of 1965.

Previous coverage in *Radiological Health Data and Rports*:

Period	Issue
January–June 1962	March 1963
July 1962–June 1963	April 1964
July–December 1963	November 1964
January–June 1964	May 1965
July–December 1964	November 1965
January–June 1965	May 1966

Table 7. Offsite water monitoring for radioactivity Mound Laboratory environs, July–December 1965

Nuclide and sampling locations [a]	Number of samples	Average concentration (pCi/liter)
Polonium-210		
2 (laboratory effluent)	24	83.8
3 (250-yards downstream)	24	0.2
4 (Chautauqua Road Bridge)	24	0.4
5 (Chautauqua Dam)	24	0.2
6 (Franklin, Ohio)	24	0.1
Trenton, Ohio	2	0.0
New Miami, Ohio	2	1.4
7 miles upstream from New Baltimore, Ohio	2	0.0
New Baltimore, Ohio	2	0.0
Miamitown, Ohio	2	0.0
Elizabethtown, Ohio	2	0.0
Hydrogen-3 (tritium)		
1 (drainage ditch)	25	320,000
2 (laboratory effluent)	25	430,000
4 (Chautauqua Road Bridge)	24	50,000
Plutonium-239		
1 (drainage ditch)	25	160

[a] See figure 4 for sampling locations.

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, OCTOBER 1966

During October 1966, no U.S. nuclear tests were reported. Detection of a Soviet test and of one detonation on the Chinese mainland was announced by the U.S. Atomic Energy Commission. On October 19, 1966, seismic signals originating from the Soviet nuclear test area in the Semipalatinsk region also were recorded. The signals were equivalent to those of a nuclear test in the low-intermediate (20 to 200 kilotons TNT) yield range.

On October 27, 1966, it was announced that the Soviet Union conducted an underground test in their northern testing area of Novaya Zemlya. Seismic signals indicated a yield within the intermediate-to-high yield range (200 kilotons to more than a megaton TNT equivalent).

Also on October 27, 1966, the Atomic Energy Commission detected a nuclear explosion in the general area of the Chinese nuclear test site at Lop Nor. Preliminary estimates indicated a yield in the low to low-intermediate range (under 20 to 200 kilotons TNT equivalent), similar to that of the first Chinese test.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

NUCLEAR POWER PRODUCTION AND ESTIMATED KRYPTON-85 LEVELS. *J. R. Coleman* and *R. Liberace. Radiological Health Data and Reports, Vol. 7, November 1966*, pp. 615-621.

Worldwide environmental levels of krypton-85 are projected to the year 2060, based on published estimates of population increase and prediction of world power needs. Factors considered include estimates of the growth of nuclear reactor power as a fraction of total power production, the "mix" of the reactor economy (thermal, thermal converter, and fast breeder systems), and the decay rate of the krypton-85 inventory. Krypton-85 buildup is discussed in relation to population dose and also to the possible effect of krypton-85 contamination on the uses of noble gases.

KEY WORDS: environmental contamination, fast breeder system, krypton-85, noble gases, nuclear energy, nuclear reactor power, population dose, thermal converter system, thermal system, year 2060.

FILM BADGE SERVICE PERFORMANCE. *D. E. Barker. Radiological Health Data and Reports, Vol. 7, November 1966*, pp. 623-626.

Approximately 2,000 film badges were irradiated with various types and energies of radiation to provide measures of film badge service accuracy upon which provisional performance control limits could be based. Exposures ranged from 2 milliroentgens to 497 roentgens. Film badge services 1) helped design the test procedures, 2) submitted badges for exposure, 3) reported exposure interpretations, and 4) assisted in determining provisional performance control limits. A measure of accuracy called an *error factor* was determined for each service for each type and energy of radiation in the test. These error factors are tabulated to show the accuracy of the film badge services tested. Frequency distributions of the error factors served as the basis for selection of provisional control limits to be used to define acceptable performance.

KEY WORDS: beta exposure, fast neutron, film badges, gamma, National Sanitation Foundation, X-radiation.

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 12, December 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service ● Division of Radiological Health

Reports

SUMMARY OF CESIUM-137 AND STRONTIUM-90 CONCENTRATIONS REPORTED IN CERTAIN ALASKAN POPULATIONS AND FOODSTUFFS 1961-1966

R. P. Chandler and *D. R. Snavely* [1]

Published data on cesium-137 and strontium-90 concentrations in certain Alaskan populations and foodstuffs, along with food consumption data, are reviewed and summarized. Where possible, concentrations in the diet and those found in people are compared to FRC guidelines. The seasonal and yearly trends of cesium-137 and strontium-90 concentrations in the diet of Alaskan populations and in people are discussed.

Considerable attention has been directed to assessing the levels and fate of radionuclides in arctic ecosystems. Because of specific dietary habits and unique ecologic situations, the levels of cesium-137 in inhabitants of arctic regions are among the highest documented. In 1960 and 1961, investigators in Norway and Sweden reported relatively high body burdens of cesium-137 in human beings, especially in residents of areas above the Arctic Circle (*1,2*). Surveys of cesium-137 body burdens carried out in 1962 for selected Alaskan residents showed body burdens similar to those found in Norway and Sweden, particularly among persons eating large quantities of caribou meat (*3*). Comparable or higher levels were subsequently found in reindeer herders in northern Finland (*4*), northern U.S.S.R. (*5*), and northern Canada (*6*).

Until 1962, studies of radionuclides in the Alaskan food chain were addressed mainly to questions associated with the proposed Project Chariot site located near Ogotoruk Creek in northwestern Alaska (*7*). Since that time, surveillance activities have continued and expanded in Alaska. The Battelle-Northwest Laboratory has studied the body burdens of cesium-137 in northern Alaskan residents (especially Anaktuvuk Pass) since the summer 1962, at which time levels were found similar to those in Norway and Sweden. The Public Health Service in April and May 1965 expanded the geographic area investigated by measuring cesium-137 body burdens throughout Alaska (*8*).

This paper summarizes selected data since 1961 relative to intake and body burdens of cesium-137 and strontium-90 in Alaskan populations. Comparison with appropriate radiation protection guidance is made where possible.

Radionuclides in foods consumed by Alaskans

The actual or potential body burdens of a specific radionuclide for a population group may be estimated from the radionuclide intake for that population group. To estimate the radionuclide intake by the population group, consumption data and the radionuclide concentration in food items consumed must be determined. Since consumption and the radionuclide concentration of specific food items may vary with location and season, and from year to year, it is important to estimate the magnitude of these variations along with average consumption and concentration values. This section summarizes data on the concentration of cesium–137 and strontium–90 found in certain indigenous Alaskan foods and in the total diet of certain Alaskan population groups. Where possible, seasonal, yearly, and location trends are shown for the various food items and/or total diet.

---

[1] Mr. Chandler was chief, Human Data Unit, Radiation Surveillance Center, and Mr. Snavely is operations officer, RSC, Division of Radiological Health, PHS, DHEW, Washington, D.C. 20201.

Caribou and reindeer

Although no well-defined range can be given for Alaskan caribou herds, the general grazing areas of the major caribou and reindeer herds, as well as the approximate number of animals in each herd, are shown in figure 1 (*9*).

Average cesium–137 and strontium–90 concentrations in caribou and reindeer muscle samples obtained by the Division of Radiological Health are listed in table 1, along with the minimum and maximum cesium–137 concentrations during the collection period. The codes in parentheses after the herd names correspond to those in figure 1. Comparison of the average cesium–137 concentrations in the caribou and reindeer muscle samples collected during December 1964 and November and December 1965 is made in figure 2. The ratio of maximum to minimum cesium–137 concentrations in muscle samples from the same herd was as large as six. These variations in cesium–137 concentrations in muscle sample taken from animals of the same herd seem to be much greater than the variations of average concentrations in muscle sample taken from animals of different herds. However, average concentrations in the Arctic herd were consistently lower and for the Teller herd consistently

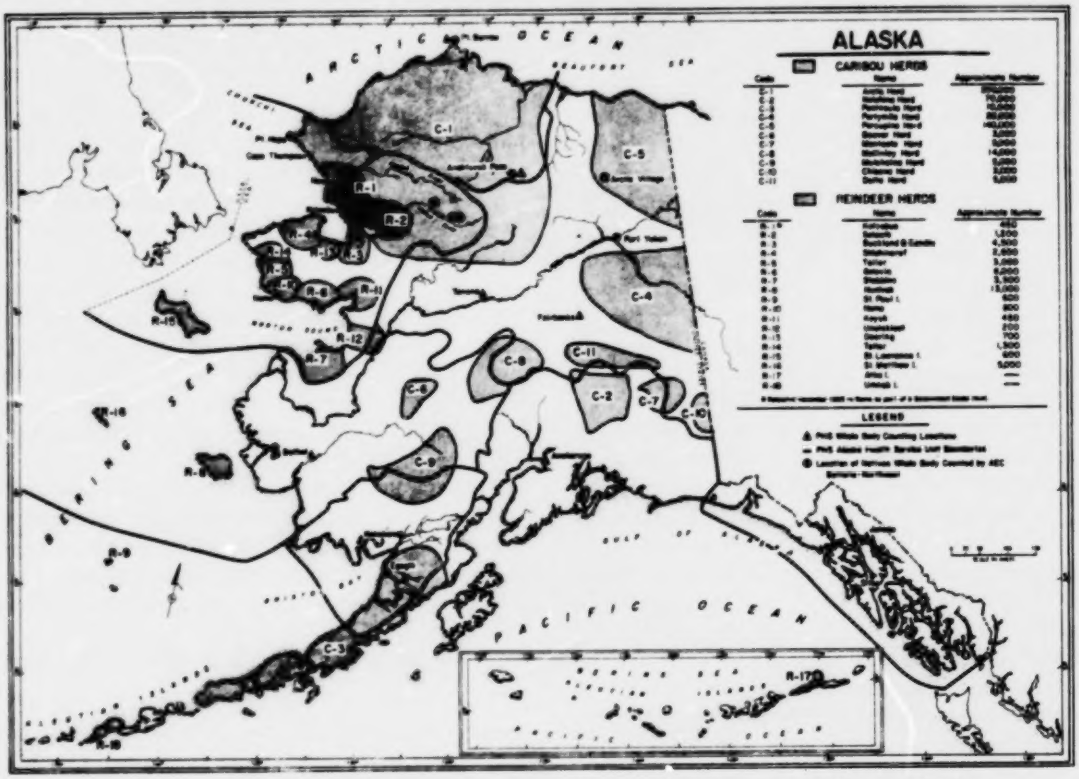

Figure 1. Map of Alaska showing location of the major caribou and reindeer herds and showing whole-body counting locations (*9*)

Table 1. Average radionuclide concentration in caribou and reindeer muscle [a]

Sampling dates	Number of samples	Concentrations in pCi/kg wet weight				
		Average strontium-89	Average strontium-90	Cesium-137		
				Average	Minimum	Maximum
Caribou						
Arctic herd (C-1)						
December 63	3	[b] <5	[b] 17	4,860	3,750	5,680
May 64	5	[b] <5	[b] 400	13,800	5,000	21,000
August 64	5	[b] <5	[b] 40	700	400	1,000
October 64	5	[b] <5	[b] 19	6,880	5,200	11,000
December 64	5	[b] <5	[b] 19	3,900	1,400	5,300
April 65	5	[b] <5	[b] 22	9,600	6,300	14,000
September 65	5	[b] <5	[b] 11	7,720	4,000	12,000
November 65	5	[b] <5	[b] 1	6,220	4,300	7,400
March 66	5	[b] <5	[b] 26	18,400	16,000	22,000
Nelchina herd (C-2)						
November 63	5	[b] 5	[b] 33	21,800	16,900	26,400
April 64	5	[b] 10	[b] 54	5,560	2,600	10,000
August 64	1	<5	31	14,300		
October 64	9	[b] 5	[b] 20	4,220	650	6,200
December 64	5	[b] <5	[b] 30	14,000	7,900	22,000
March 65	5	[b] <5	[b] 48	27,600	16,000	39,000
July 65	5	[b] <5	[b] 7	4,000	1,600	7,300
September 65	5	[b] <5	[b] 26	8,160	5,900	10,000
December 65	5	[b] <5	[b] 33	17,200	16,000	22,000
Peninsula herd (C-3)						
December 63	5	[b] 10	[b] 84	44,800	33,600	57,700
April 64	5	[b] <5	[b] 14	14,800	12,000	18,000
July 64	4	[b] <5	[b] 5	1,680	1,400	2,000
September 64	5	[b] <5	[b] 11	4,630	1,200	9,250
December 64	5	[b] <5	31	18,000	8,700	31,000
August 65	5	[b] <5	[b] 4	2,000	820	3,200
September 65	5	[b] <5	[b] 15	18,000	11,000	32,000
November 65	5	[b] <5	[b] 7	20,100	12,400	25,000
March 66	5	[b] <5	[b] 18	43,800	41,000	46,000
Reindeer						
Kotzebue herd (R-1)						
December 63	4	[b] <5	[b] 31	7,190	6,730	7,540
September 64	5	[b] <5	[b] 74	3,340	2,300	4,900
December 64	4	[b] <5	[b] 268	23,000	13,000	30,000
Selawik herd (R-2)						
December 64	1	<5	578	[c] 34,000		
Buckland and Candle herd (R-3)						
September 64	2	[b] <5	[b] 68	19,600	13,400	25,800
December 64	4	[b] <5	[b] 64	14,000	5,100	32,000
Shismaref herd (R-4)						
September 64	3	[b] <5	[b] 38	8,490	7,660	10,100
December 64	5	[b] <5	[b] 68	12,000	4,900	29,000
March 65	5	[b] <5	[b] 25	18,000	13,000	24,000
September 65	5	[b] <5	[b] 14	6,000	4,000	8,100
November 65	5	[b] <5	[b] 25	16,800	14,000	22,000
February 66	5	[b] <5	[b] 55	18,400	15,000	23,000
Teller herd (R-5)						
December 64	5	[b] <5	[b] 66	35,000	25,000	47,000
November 65	5	[b] <5	[b] 90	27,000	23,000	35,000
June 66	5	[d] —	—	19,000	17,000	21,000
Golovin herd (R-6)						
December 64	5	[b] <5	[b] 96	19,000	11,000	30,000
Stebbins herd (R-7)						
December 64	5	[b] <5	[b] 86	30,000	14,000	37,000
Nunivak Island herd (R-8)						
September 64	5	[b] <5	[b] 75	7,050	5,000	9,200
December 64	5	[b] <5	[b] 128	25,000	9,800	35,000
April 65	5	[b] <5	[b] 28	31,200	27,000	34,000
August 65	35	—	—	7,700	4,000	15,000
January 66	5	[b] <5	[b] 90	27,200	25,000	31,000
April 66	5	[b] <5	[b] 21	33,400	32,000	34,000
St. Paul Island herd (R-9)						
September 64	4	[b] <5	[b] 10	4,860	2,060	7,530
November 64	5	—	—	13,000	4,400	16,000
Nome herd (R-10)						
June 66	5	—	—	22,000	17,000	27,000
Deering herd (R-13)						
December 64	5	[b] <5	[b] 127	28,000	23,000	34,000

[a] Data reported by USPHS in table 1, reference (*11*). Includes recent additions and corrections.
[b] indicates samples composited before analysis.
[c] Only one sample collected.
[d] Dash indicates no analysis.

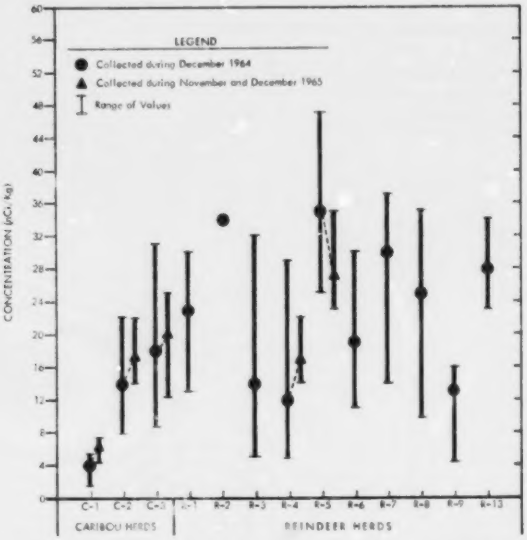

Figure 2. Comparison between average cesium-137 concentrations in Alaskan caribou and reindeer muscle samples collected during December 1964 and during November and December 1965. Values are from table 1.

higher than concentrations in other herds during both periods.

Hanson (*12*) has reported differences in cesium-137 concentrations in caribou flesh samples collected from various areas within the range of the Arctic caribou herd. Concentrations found in caribou flesh samples taken at different locations during the summer are listed in table 2.

Seasonal variations of cesium-137 concentrations in muscle samples were observed in the three caribou herds and two reindeer herds sampled, as shown in figure 3. For the arctic herd, data from both the USPHS Laboratory and the Battelle Pacific Northwest Laboratory are presented. Although the trends are the same, average values reported by the two laboratories vary by a factor of 3 to 6 for those samples collected the same month. On split samples (taken from the same animals) analyzed by the USPHS and the Battelle Pacific Northwest Laboratory, the same difference has been observed. Attempts are being made to explain this difference, but so far no satisfactory explanation has been found. Average concentrations in winter samples were from 3 to 25 times higher than those collected in summer, with peak concentrations in those samples collected near the end of winter and the lowest concentrations in those collected near the end of summer. Not enough samples for the other herds were obtained throughout the year to observe a seasonal variation. Except for the arctic herd, the strontium-90 concentration in muscle samples followed the same seasonal variations as cesium-137, as shown in figure 3. The strontium-90 concentrations in muscle samples from the arctic herd appear to follow no definite pattern.

Table 2. Concentration of cesium-137 in caribou flesh at various locations in northern Alaska during summer period 1960–1964 [a]

Location	Cesium-137 (pCi/g dry weight)				
	1960	1961	1962	1963	1964
Anaktuvuk Pass	------	3.8	12	16	17
Cape Thompson	2.5	5.0	8.1	16	------
Noatak-Kobuk Rivers	7.7	40	------	13	360
Fort Yukon-Arctic Village	------	------	21	51	150

[a] Data reported by Hanson in table 1 (*12*)

The ratios of average cesium-137 concentrations to average strontium-90 concentrations for each sampling of each herd are plotted with time in figure 4. The average ratio of cesium-137/strontium-90 for the five herds is 750, as compared to 800 reported by Hanson for caribou flesh samples collected in northwestern Alaska (*12*).

For comparison purposes, average cesium-137 and strontium-90 concentrations in muscle samples collected during specific time periods each year are presented in table 3. Data given for May and June are from Battelle-Northwest; data given for November and December are from the USPHS. The concentrations in caribou muscle samples from the arctic herd collected during May and June of 1962, 1963, and 1964 show a definite yearly increase, approximately doubling each year.

Yearly trends are not apparent from comparison of cesium-137 concentrations in muscle samples obtained from the three caribou herds during the November to December periods of 1963, 1964, and 1965 nor in samples obtained from two reindeer herds during the November to December periods of 1964 and 1965. February or March would probably be a better period for comparison, since the animals would have had a longer period to reach equilibrium with their

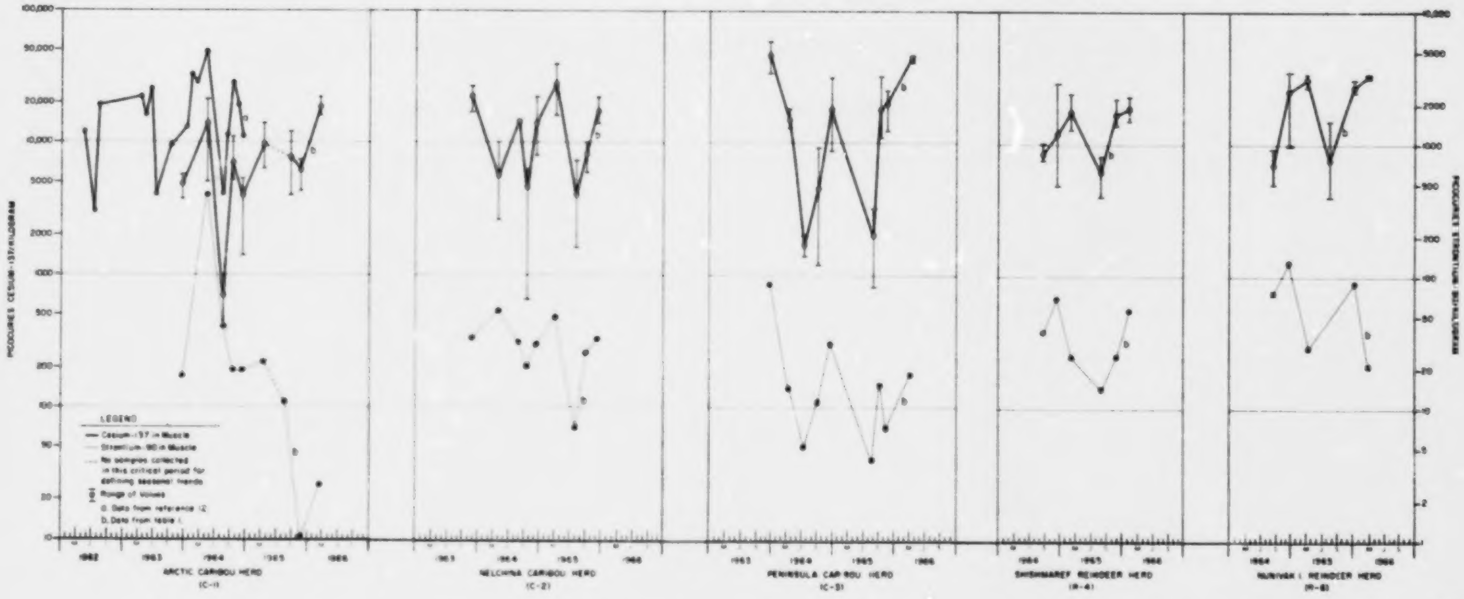

Figure 3. Seasonal trends of cesium-137 and strontium-90 concentrations in Alaskan caribou and reindeer muscle

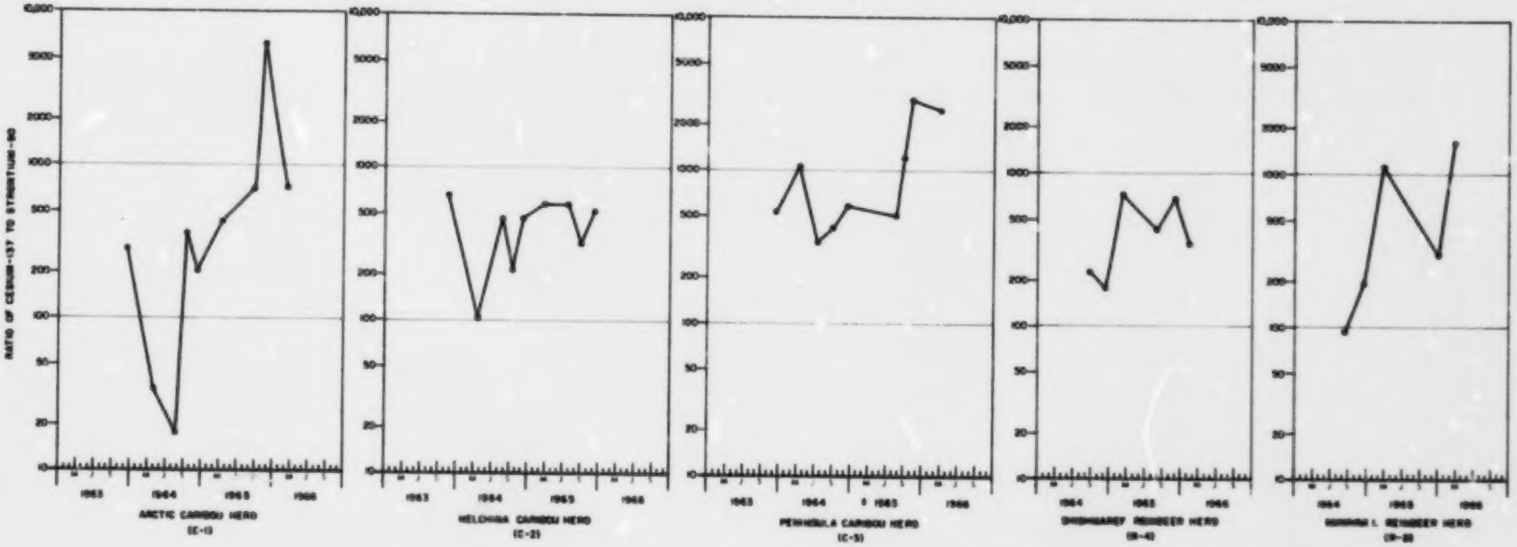

Figure 4. Ratio of cesium-137 to strontium-90 in caribou and reindeer muscle versus time

Table 3. Cesium-137 and strontium-90 concentrations, pCi/g wet weight, in caribou and reindeer muscle samples

Herd	May 1962 average [a]	June 1963 average [a]	May 1964 average [a]	November-December 1963 average [b]		December 1964 average [b]		November-December 1965 average [b]	
	Cesium-137	Cesium-137	Cesium-137	Cesium-137	Strontium-90	Cesium-137	Strontium-90	Cesium-137	Strontium-90
Arctic caribou (C-1)	12,000	25,000	48,000	4,860	17	3,900	19	6,220	1
Nelchina caribou (C-2)	—	—	—	21,800	33	14,000	30	17,200	33
Peninsula caribou (C-3)	—	—	—	44,860	84	18,000	31	20,100	7
Shismaref reindeer (R-4)	—	—	—	—	—	12,000	68	16,800	25
Teller reindeer (R-5)	—	—	—	—	—	35,000	66	27,000	90

[a] Abstracted from figure 3 (Battelle-Northwest data.)
[b] Abstracted from table 1 (USPHS data).

winter diet of lichens and moss; however, no samples were collected during February or March for all 3 years. The November to December 1964 cesium–137 averages for the three caribou herds were less than the November to December 1963 averages by approximately one half. The November to December 1965 cesium–137 averages increased slightly over the November to December 1964 averages for the three caribou herds and one reindeer herd. This suggests that cesium–137 concentrations in lichen and mosses have started to level off in 1964 and may be nearing a plateau. Variations in cesium–137 concentrations in muscle, taken from the same herd during November and December 1963, 1964, and 1965, may be due to variations in the grazing areas (which would vary in cesium–137 concentration depending on plant type, etc., of the animals from year to year and not necessarily due to any large increase or decrease in lichen or moss cesium–137 concentrations. This is supported by Hanson's findings at Anaktuvuk Pass where he found that cesium–137 concentrations in lichens maintained nearly constant values from January 1964 through March 1965 (*12*). Trends of strontium–90 concentrations in muscle samples did not necessarily follow trends in cesium–137 concentrations.

From the data in figure 3, cesium–137 muscle concentrations of caribou and reindeer never reached equilibrium in the winter months but started to increase in September continuing through the winter months, indicating that the cesium–137 intake was not constant. (Assuming a constant intake of cesium–137 and a biological half-life of 30 days in caribou and reindeer (*13*), about 90 percent of the equilibrium value is reached in 100 days.) The cesium–137 intake is a function of many factors which include the food available, which in turn depends on the migratory pattern of the herd, and the cesium–137 concentration in the different plants grazed. Consequently, for predicting long-range trends of cesium–137 in caribou, the rate of change of levels in their food may be more suitable. During the winter months, lichen has been shown to be the principal source of cesium–137 for caribou in the Arctic regions (*5,13*). Consequently, when levels in lichen decrease, levels in caribou should also decrease. The Battelle-Northwest Laboratory has been studying cesium–137 concentrations in lichen since 1959, and Hanson reported (*14*) that measurements made at Anaktuvuk Pass during the first few months of 1965 suggested that the period of maximum rate of buildup was past, but that there was not enough information to accurately predict future levels.

For short-term predictions of cesium–137 concentrations in man, it is important to sample when the animals are actually killed for food, since both seasonal and yearly variations have been observed in the caribou and reindeer cesium–137 and strontium–90 muscle sample concentrations. Although detailed information is not available on which villages or people depend on the various herds for food and the time or times of year when they hunt, general statements can be made in regard to the three caribou herds and the reindeer herds located in the Kotzebue and Norton Sound areas and the herd on Nunivak Island.

Only the Eskimos at Anaktuvuk Pass have been identified as depending on meat from the Arctic herd during the entire year. The fact that part of the Arctic caribou herd migrates through the Pass to get to their winter

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or summer range makes the hunting habits of the residents of Anaktuvuk Pass unique (*10*). Almost all of the animals are obtained during one of two periods of the year: during September and October, when the animals are migrating through the Pass to their winter range and April and May, when the animals are migrating back to their summer range (*10*). The animals taken are used as a continuous meat supply (*14*). No other village is believed to depend on the Arctic caribou herd for food the year round; other villages take from this herd when it is in their area. Since this herd has no definite migratory pattern, it may not pass a village for 2 or 3 years.

On the other hand, only a few animals are believed to be taken from the Nelchina and Peninsula caribou herds by natives. The majority are taken by sports hunters during the hunting season (September through March), with most of the animals obtained in October and November (*10*).

The reindeer are usually slaughtered in the fall. Reindeer from the Kotzebue Sound and the Norton Sound areas are consumed locally, but reindeer meat from the government-owned herd on Nunivak Island is shipped to the lower Kuskokwim River Basin, Anchorage, Fairbanks, Juneau, and Seattle, Washington (*10*).

Table 4. Cesium-137 concentrations in the meat of caribou and moose samples [a]

Collection date	Cesium-137 concentrations, pCi/g dry weight							
	Anaktuvuk Pass		Kobuk-Noatak River		Fort Yukon		Cape Thompson	
	Caribou	Moose	Caribou	Moose	Caribou	Moose	Caribou	Moose
July 63			13(6)	5.3(1)				
August 63							16(5)	4.4(1)
September 63					48(11)	2.2(1)		
October 63	[b] 36(10)	4.7(1)						
March 64			190(4)	5.6(2)				
April 64					150(6)	2.6(3)		

[a] Data reported by Watson *et al.* in table 3 (*15*)
[b] Number in parentheses gives number of animals.

Moose

Watson *et al.* (*15*) reported cesium–137 concentrations in caribou and moose collected from the same location during the same month. In table 4 a comparison is made between levels found in caribou and those found in moose. Concentrations in caribou samples exceeded those in moose samples collected in the same locations and time periods by a factor of 3 to 50. Results of moose muscle samples collected in Canada indicated that cesium–137 levels were at least an order of magnitude below levels in caribou and reindeer muscle (*6*). Consequently, moose meat presents a much lower potential for cesium–137 intake than caribou or reindeer meat. Reasons given for the lower cesium–137 concentrations in moose muscle are the absence of lichen and possible plant litter in their diet (*15*).

Fish

Analytical results for single samples of freshwater and marine fish collected in Alaska and analyzed by the USPHS are listed in table 5. From these data very little can be said concerning comparison between the radionuclide concentrations in freshwater or marine fish, or any seasonal variations in radionuclide concentrations. However, Watson and Richard (*16*) made a study during the summer of 1962 of the radionuclide concentrations in Alaskan fishes in the vicinity of Cape Thompson. Samples were taken from the Arctic Ocean, Marryatt Lagoon, the Kukpuk and Noatak Rivers, and Kelly and Phalarope Lakes. Cesium–137 was not detected in marine fish. Concentrations were highest in the lake fish, approximately a factor of 10 greater than those in fish from the rivers or lagoon. Kolehmainen *et al.* (*17*)

Table 5. Cesium-137 and strontium-90 concentrations in freshwater and ocean fish [a]

Common name	Collection date	Cesium-137 (pCi/kg)	Strontium-90 (pCi/kg)
Freshwater			
Grayling	8/15/64	100	31
White fish	12/15/64	15	217
Ocean			
Dog salmon	8/15/64	65	38
Dog salmon	8/15/64	70	38
Dog salmon	8/15/64	470	38

[a] Unpublished USPHS data.

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found in Finnish lakes that the cesium-137 concentration in freshwater fish of the same species varied inversely with potassium content of the water.

Milk

Monthly cesium-137 and strontium-90 averages in pasteurized milk for Palmer, Alaska (near Anchorage), are plotted in figure 5 and 6, respectively. For comparison, the Public Health Service's Pasteurized Milk Network national monthly average, maximum, and minimum values are also plotted. The data for the Palmer, Alaska, samples are very similar to the network averages. In no case did the cesium-137 concentration in Palmer milk approach the maximum concentration for the network; the strontium-90 concentration approached the maximum in late 1961, during a period when all concentrations were below 20 pCi/liter. It is not surprising that the concentrations of cesium-137 and strontium-90 in Palmer milk are similar to the Pasteurized Milk Network averages, since both fallout levels (*18*).

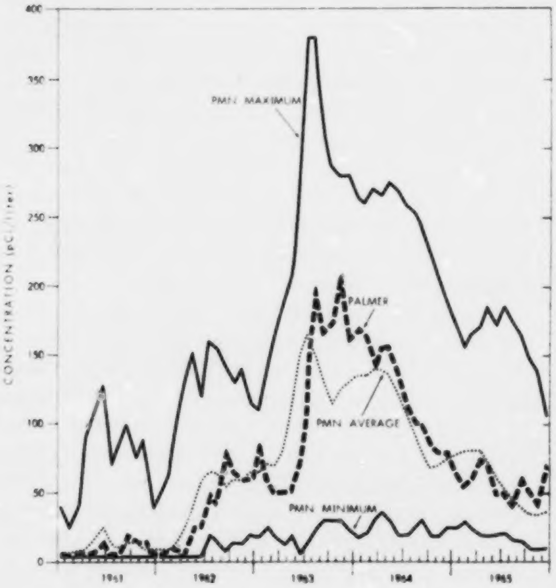

Figure 5. Comparison of the PHS Palmer, Alaska, average monthly concentration of cesium-137 in pasteurized milk to the PHS Pasteurized Milk Network monthly average, maximum, and minimum concentrations (*35*)

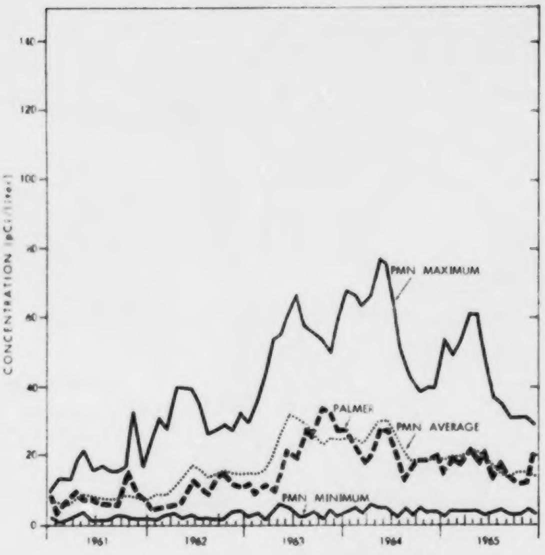

Figure 6. Comparison of the PHS Palmer, Alaska, average monthly concentration of strontium-90 in pasteurized milk to the PHS Pasteurized Milk Network monthly average, maximum, and minimum concentrations (*35*)

Total diet and other foods

Average monthly intakes of strontium-90 and cesium-137 via the total diet since October 1961 from the Public Health Service's Institutional Total Diet Sampling Network station at Palmer, Alaska, are plotted in figures 7 and 8. Designed to estimate the dietary intake of radionuclides by school-age children, the program samples the diets of children at Palmer ranging in age from 6 to 18 years. Details of the program have been described previously (*19*). As observed in figure 7 and 8, the Palmer samples have had the maximum cesium-137 intake for the network in only 4 out of 60 sampling periods; strontium-90 concentrations in Palmer food samples were the peak values of the network in only 3 out of 60 periods. These intake levels are representative mainly of the Matanuska Valley and not of areas where caribou or reindeer consumption is high.

Cesium-137 and strontium-90 concentrations in whale and seal samples taken in Alaska in 1964 and analyzed by the USPHS are listed in table 6. The cesium-137 concentrations are similar to beef samples collected in October 1965 from Chicago, Illinois (*20*).

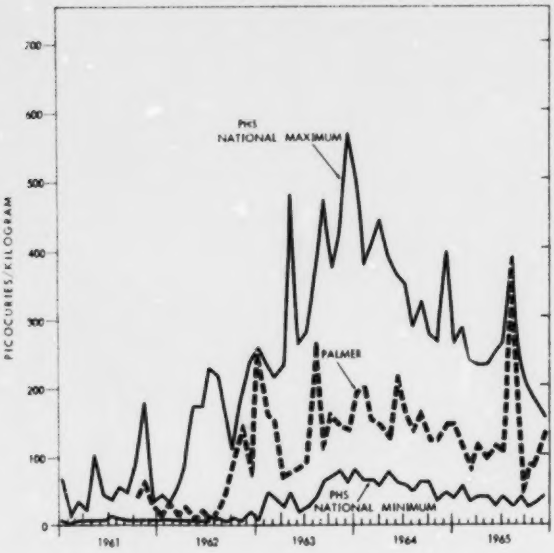

Figure 7. Comparison of the PHS Palmer, Alaska, estimated dietary cesium-137 intake to the estimated maximum and minimum cesium-137 intake through PHS Institutional Total Diet Sampling Network (*36*)

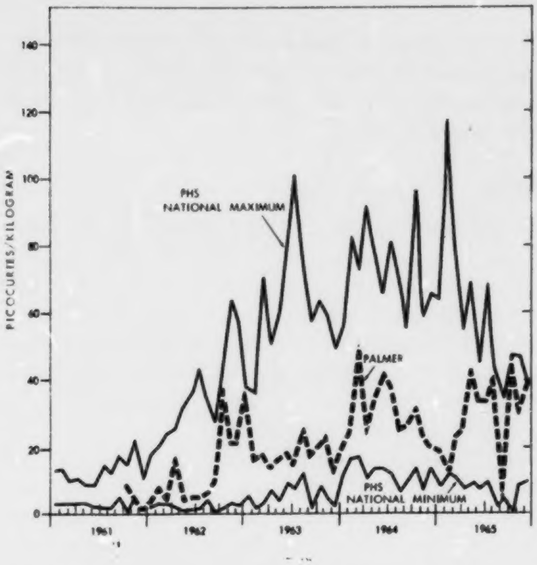

Figure 8. Comparison of the PHS Palmer, Alaska, estimated dietary strontium-90 intake to the estimated maximum and minimum strontium-90 intake through PHS Institutional Total Diet Sampling Network (*36*)

Table 6. Cesium-137 and strontium-90 concentrations in whale and seal muscle [a]

Animal	Collection date	Cesium-137 (pCi/kg)	Strontium-90 (pCi/kg)
Whale	9/15/64	160	16
Whale	10/15/64	110	16
Bearded seal	12/15/64	65	95
Hair seal	12/15/64	15	15

[a] Unpublished USPHS data.

Radionuclide burdens in Alaskan populations

Data for body burdens of radionuclides in human beings in Alaska are fewer than data on concentrations in foods due, in part, to the greater expense and difficulty of measuring human body burdens *in vivo* compared to that of measuring radioactivity in foods, the large land area involved, and the difficulty and expense of collecting appropriate human organs as a result of surgical procedures or post-mortem. Selected data on cesium-137 and strontium-90 body burdens are presented below.

Cesium-137

Battelle-Northwest Laboratories and the Public Health Service have conducted whole-body counting of Alaskan residents. The former used both a shadow shield technique (*21*) and an unshielded sodium iodide crystal technique while the latter used an unshielded sodium iodide crystal technique (*8*). Table 7 lists mean and maximum cesium-137 body burdens measured by whole-body counting of adult Alaskan residents through the spring of 1966. The time of measurement and the groups doing the measuring are indicated. The highest body burden found is not given in the table but was reported as 3,000 nCi for a non-native counted in the summer of 1964. He was reported to be in the village of Ambler and to have a diet consisting mostly of caribou meat (*22*).

A rise in body burdens for those Alaskan residents counted in the summer is evident through 1964. The average 1964 summer body burdens at Anaktuvuk Pass were triple those of summer 1962. However, the average adult summer body burdens in 1965 were only 70 percent of the summer 1964 average (*23*). The average body burdens for Alaskan residents counted at the same location in spring 1965 and 1966 decreased in every case. Also, Fitzpatrick *et al.* reported that for subjects counted both in spring 1965 and 1966, the maximum and average body burdens decreased at each location, with the exception of Kanakanak and Tanana,

Table 7. Mean total cesium-137 body burdens in adult Alaskan residents [a]

Location [b]	Summer 1962			Summer 1963			Summer 1964			Spring 1965			Summer 1965			Spring 1966		
	Avg (nCi)	Max (nCi)	Ref	Avg (nCi)	Max (nCi)	Ref	Avg (nCi)	Max (nCi)	Ref	Avg (nCi)	Max (nCi)	Ref	Avg (nCi)	Max (nCi)	Ref	Avg (nCi)	Max (nCi)	Ref
Anaktuvuk Pass	421	790	*22*	628	1,240	*22*	1,280	2,400	*22*	[e]1,052	1,368	*8*	920	1,740	*24*	680	1,040	*24*
Anchorage										70	206	*8*				60	850	*24*
Arctic Village							614	1,156	*22*									
Barrow	52	166	*22*	60	177	*22*										160	440	*24*
Bethel										93	293	*8*				40	200	*24*
Coastal Villages [c]	100		*12*				130		*12*									
Egegik																250	820	*24*
Fairbanks																20	190	*24*
Fort Yukon				34	181	*22*												
Juneau																10	<40	*24*
Kanakanak										178	1,279	*8*				120	1,100	*24*
Kotzebue	138	518	*22*	140	732	*22*	321	929	*22*	454	979	*8*				240	1,390	*24*
Little Diomede	22	35	*22*															
Mt. Edgecombe										43	138	*8*				20	70	*24*
Point Hope	17	119	*22*	39	88	*22*	50	92	*22*									
River Villages [d]	150		*12*	150			360		*12*									
Selawik																1,250	2,400	*24*
Tanana										44	88	*8*				30	160	*24*

[a] For USPHS data, males only were counted.
[b] For USPHS data, the location represents the counting location. Persons counted were from the location and from outlying villages.
[c] Kivalina, Deering, Elim.
[d] Noatak, Selawik, Noorvik, Kiana, Shungnak, Kobuk, Ambler.
[e] Based on measurements of three people eating large amounts of caribou.

where slightly higher maximums and minimums were observed (*24*). Forty-nine subjects were counted both years, and the average decreased from 280 nCi in 1965 to 140 nCi in 1966. Of the new counting locations added in 1966, Selawik had the highest body burdens. The average and maximum body burdens at Selawik were similar to those at Anaktuvuk Pass during the summer of 1964. Selawik is located near many reindeer herds, and the levels comparable to those at Anaktuvuk Pass may be due to a relatively large consumption of reindeer meat.

Hanson (*25*) found from a study begun in January 1964, in which Anaktuvuk Pass Eskimos were counted approximately every 2 months, that body burdens showed a definite seasonal pattern with lowest values occurring during January and highest during July. He explains that this results from the Eskimos killing a supply of caribou when the animals pass near their village in the fall and spring (fall caribou are lowest in cesium–137 content and spring caribou are highest). The meat is stockpiled for use until the next slaughter period. Consequently, caribou meat used during the winter is much lower in cesium–137 content than that used during the late spring and summer months. The winter meat supply is supplemented by fresh meat obtained from animals found within a few miles of the village. The cesium–137 content of these animals increases as the winter progresses. Hanson (*25*) also reports that cesium–137 body burdens were highest for men and lowest for children in the Anaktuvuk Pass studies. However, there appeared to be no difference between males and females up to age 20. Maximum body burdens were observed for persons between 40 and 60 years of age.

Strontium–90

The skeleton is the critical organ for ingestion of strontium–90 (*26*). Limited numbers of bone samples from Alaska have been obtained through the Public Health Service Human Bone Network (*27–30*). Samples were obtained from surgical procedures at two PHS Alaska Health Service hospitals, which treat patients from surrounding areas (figure 1). At the present time, strontium–90 concentrations in only a few samples have been reported.

Table 8 lists results of analyses by age at time of surgery, type of bone, place and date of surgical procedure, and pCi strontium–90/g calcium for samples collected at the two hospitals during 1964 and 1965. Figure 9 indicates individual Alaskan bone samples compared with the average and range for all the samples col-

Table 8. Strontium-90 in individual rib samples [a]

Age of obtained specimen	Place of obtained specimen	Date of procurement	Strontium-90 (pCi/g Ca)
2	Mt. Edgecumbe	6/64	3.23
12	Anchorage	5/65	3.13
17	Anchorage	4/65	4.31
17	Anchorage	3/65	4.71
20	Anchorage	9/64	2.62
22	Anchorage	3/65	1.28
23	Mt. Edgecumbe	4/64	0.62
23	Anchorage	10/64	3.91
25	Anchorage	4/65	1.17
Average			2.78

[a] Data from references (*27–30*) and USPHS basic data files

lected in the United States during 1964 and first quarter 1965.

The Alaskan samples were rib bones and the levels were similar to the U.S. yearly and quarterly averages for all bones (the majority were vertebrae) in the network. Kulp *et al.* (*31*) reported the ratio of strontium–90 concentrations in individual bones to concentrations in the whole skeleton as 2.1 for vertebrae, 1.4 for ribs, 0.45 for long-bone shaft. Skeletons were from adult individuals who died in 1958 and 1959 in New York. Although it would be better to compare the Alaskan samples with the U.S. average for rib bones only, most of the Alaskan samples are still in the range of the U.S. average when multipled by 1.5 (2.1 vertebrae/1.4 rib).

Dietary studies in Alaska

A dietary survey made by the Arctic Health Research Center (*32*) on Alaskan Eskimo and Indian diets has shown an extreme variation in individual mean daily intake of 11 major nutrients. They also found that the use of imported foods was limited in the villages and that the supply of local foods fluctuated from season to season and year to year. Use of different meat and fish products varied considerably in the 11 villages studied. The average estimated daily intake of meat or fish for an individual in a native village in the northern coastal areas was 1.5 lbs. (0.68 kg), and on occasion an individual might consume as much as 5.5 to 6 lbs (2.5 to 2.7 kg).

Hanson and Palmer report the estimated weekly consumption of caribou meat by the natives of Anaktuvuk Pass as 5 to 6 kg fresh weight with the exception of late 1963 (*14*). This would amount to an average daily intake of caribou meat of approximately 0.8 kg.

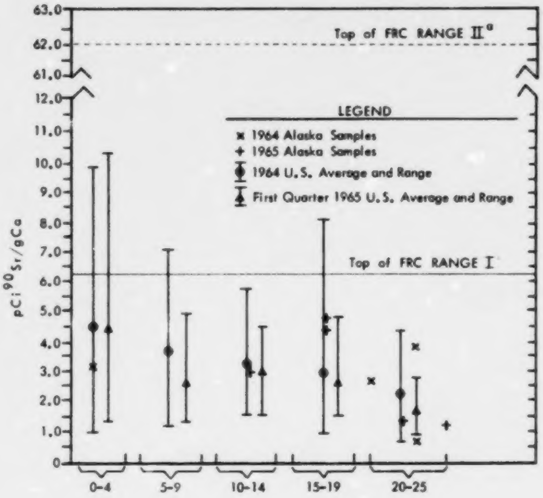

Figure 9. Strontium-90 in Alaskan bone samples as compared to other U.S. bone samples

[a] Calculation based on the upper value of FRC range II, which corresponds to a dose for continuous intake at that level equal to one-ninth of the RPG for the individual, and the FRC assumption that 1 nanocurie of strontium-90 per gram calcium in the bone gives a dose to the bone marrow of 0.9 rad in 1 year (*26, 34*)

Hanson and Palmer (*33*), in conducting their whole-body counting measurement in northern Alaska in 1962 and 1963, also obtained dietary information. For study purposes they chose villages which depended heavily, and other villages which depended less, on caribou meat (river and coastal villages). Also studied was a native village at Fort Yukon which used moose as a major food source during the fall and winter months. Of the natives studied at the six locations—Anaktuvuk Pass, river villages (villages on the Noatak and Kobuk Rivers), Barrow, Kotzebue, Point Hope, and Fort Yukon—it was found that native animals contributed about 40 to 70 percent of the total diet by weight. They found caribou to be most important in the diet of natives at Anaktuvuk Pass and least important at Fort Yukon. The highest consumption of reindeer meat was by Barrow and Kotzebue residents, to supplement caribou. Moose meat was found to be most important in the Fort Yukon diets. Walrus (*Odobenus rosmarus*), ringed seal (*Phoca* [*Pusa*] *hispida*), and the bearded seal or ugruk (*Erignathus* *barbatus*) were the most important marine mammals taken by all Eskimos.

Hanson and Palmer (*33*) also point out that a variety of fish and birds are utilized depending upon the village and season. Fish include arctic char (*Salvelinus alpinus*), grayling (*Thymallus articus*), tomcods (*Boreogadus saida*), whitefish (*Coregonus spp.*), and salmon (*Oncorhynchus spp.*). Birds include eiders, murres, and auklets for coastal Eskimos; and ducks and ptarmigan for river village Eskimos. Greatest use of imported foods was found in villages which employed natives in a local industry. The wages allowed them to buy more food and the work restricted their hunting activities.

Levels with respect to diet and Federal Radiation Council Guidelines

In FRC Report No. 7, Section 4.9 (*34*), the Federal Radiation Council gives guidance on the Alaskan situation. Since cesium–137 is distributed throughout the body, recommendations for whole-body exposure apply. The appropriate Radiation Protection Guides are 0.5 rem/year for individuals in the general population when measured directly or an average of 0.17 rem/year to a suitable sample of a population group, when direct measurement is not made. The FRC further states that "an annual average body burden in adults of 3,000 nanocuries and 1,000 nanocuries would be estimated to result in these respective doses." Of the maximum values for the various locations given in table 7, all were below the FRC guidance of 3,000 nanocuries. The highest was 80 percent of the guidance. The maximum body burden for an Alaskan resident as reported previously was 3,000 nanocuries (the FRC Radiation Protection Guides for an individual). He was counted during the summer of 1964 and was reported to consume unusually large amounts of caribou meat. The average body burdens in table 7 were above 1,000 nanocuries at Anaktuvuk Pass for the summer of 1964 and at Selawik for the spring of 1966. However, in both of these cases the maximum burdens were less than a factor of 3 of the average indicating that the individuals measured in the locality were not exceeding the individual RPG.

Relation of dietary information to cesium–137 body burdens indicated that there was a direct correlation between cesium–137 body burdens and caribou consumption (*8,24,33*) and that caribou is the major source of dietary cesium–137 intake for those groups with elevated levels. Lower amounts of cesium–137 were found for natives who ate appreciable amounts of fish, marine mammals, or processed food (*25*). The maximum cesium–137 value for caribou in figure 3 was that reported by Hanson in May 1964 of 48,000 pCi/kg fresh weight. The lowest average value in figure 3 reported by PHS was 700 pCi/kg collected in July 1964. If a daily intake of caribou meat of 0.8 kg is assumed and cesium–137 in the diet is in equilibrium with that in the people consuming the meat, the above values would correspond to cesium–137 body burdens of 5,530 and 81 nCi, respectively (biological half-life of 100 days assumed). However, the body burden will reach only 90 percent of equilibrium conditions, from the start of intake of contaminated meat at a given cesium–137 level, in about 330 days. It has been shown that cesium–137 levels in caribou meat vary considerably with season. Consequently, levels in individuals consuming caribou or reindeer meat would highly depend on the time of year the meat they consumed was obtained. There is no evidence that any group of people who live on caribou or reindeer meat the year round kill animals only in late winter or early spring. In fact, evidence is to the contrary; most of the reindeer are slaughtered in the fall. Measured cesium–137 body burdens support this fact as none have approached the 5,530 nCi figure. All other food samples reviewed in this paper are orders of magnitude below caribou or reindeer muscle in cesium–137 concentration, although for some items only two or three samples were reported.

Using the factor of 1 nCi strontium–90/g calcium in the bone as yielding a dose to the bone marrow of 0.9 rad in 1 year (*34*) and assuming linear proportionality, a value of 556 pCi strontium–90/g calcium in bone would yield the numerical value of the individual RPG (0.5 rad) in 1 year. The highest strontium–90 level in the few Alaskan bone samples analyzed was 7.95 pCi/g calcium or about 1 percent of the RPG. More data are needed to characterize

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more fully the body burdens of this nuclide in the Alaskan population. Especially needed are bone samples from those ethnic groups which consume relatively large amounts of caribou or fish, or whose diet is not the typical western diet.

The highest concentration of strontium-90 in Alaskan foods summarized in the article was 578 pCi/kg reported for a sample collected in December 1964 from the Selawik reindeer herd. If a daily consumption of 0.8 kg of reindeer meat is assumed, consumption of meat contaminated to this level would result in a strontium-90 daily intake of 460 pCi/kg, approximately twice the day value of FRC range II for strontium-90 (*26*) of 200 pCi/day. However, this guidance is for continual intake at this level; and concentrations reported for caribou and reindeer samples collected before and since December 1964 have been much lower than the 578 pCi/kg value. Also, a continuous daily intake of strontium-90 at the upper limit of FRC range II results in an estimated bone marrow dose rate of only one-third the RPG for the average of a suitable sample of an exposed population group (0.17 rem/year) (*26*).

Summary

Data have been reviewed and summarized for cesium-137 and strontium-90 concentrations in certain Alaskan populations and foodstuffs. The highest cesium-137 body burden reported in Alaska was during the summer of 1964 and equal to the FRC Radiation Protection Guides of 3,000 nCi. The burden was found in a non-native who was reported to have a diet consisting mostly of caribou meat. The average Alaskan body burdens reviewed in this report increased through the summer of 1964 but since have decreased through the spring of 1966 when body burdens from the same location and season of the year were compared. Average body burdens were all below the RPG for a suitable sample of a population group except for two locations. However, at these locations all individual body burdens measured were below the RPG for individuals. Dietary studies indicated that cesium-137 body burdens were directly related to caribou consumption, the major source of cesium-137 for those groups with elevated levels. There is no evidence that other foods contributed a major amount to the elevated levels. Levels in foodstuffs substantiated this fact with maximum levels in caribou and reindeer flesh orders of magnitude above other foods. There are seasonal variations in caribou and reindeer flesh samples with winter concentrations 3 to 25 times the summer concentrations. However, since December 1963, cesium-137 concentrations in caribou and reindeer show no definite trends upward or downward when comparing the concentrations in samples collected from the same herd and time period each year. This seems consistent, since levels in lichens at Anaktuvuk Pass were reported nearly constant from January 1964 through March 1965. The variations after January 1964 in the cesium-137 concentrations in samples from the same herd when comparing the same time period each year are probably due to the animals grazing in different areas and the differences in types and amounts of food available each year.

There is little data on strontium-90 concentrations in human bone samples of Alaskan residents. For the few reported, concentrations are similar to the U.S. average. However, the dietary habits of the ethnic groups which these bones represent are not available. The highest strontium-90 concentration in Alaskan foods reviewed in the paper was 578 pCi/kg in reindeer meat collected in December 1964. A daily consumption of 0.8 kg of meat contaminated to this level results in a strontium-90 intake level about twice the upper value of FRC range II.

However, this guidance is for continual intake at this level and concentrations reported for caribou and reindeer samples collected before and since December 1964 have been much lower than the 578 pCi/kg value. Also, a continuous daily intake of strontium-90 at the upper limit of FRC range II results in an estimated bone marrow dose rate of only one-third the RPG for the average of an exposed population group.

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(10) Information on migration and grazing habits of each herd, slaughtering periods, approximate seasons, and consumption of meat was supplied for caribou by Terry McGowan, Caribou Project Leader, and Kenneth Neiland, Parasitologist, Alaska Department of Fish and Game; and for reindeer by David O. Scott, Jr., Range Conservationist of the Bureau of Indian Affairs, U.S. Department of Interior.

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CESIUM-137 BODY BURDENS IN ALASKAN MEN, SPRING 1966

D. E. P. Fitzpatrick, J. L. Russell, O. G. Briscoe, and *C. R. Calvert*[1]

The cesium-137 body burdens of caribou-eating Alaskan men continue to be elevated, although in general the average body burdens are decreasing compared to those observed in 1965. Elevated cesium-137 body burdens are well correlated with caribou (reindeer) consumption, and non-caribou eaters exhibit cesium-137 body burdens similar to residents in the conterminous United States. During the 1966 study, the cesium-137 body burden of a total of 418 Alaskan men was obtained. The body burdens observed ranged from 2,400 to less than 40 nCi and indicated a wide range of values depending on location.

During the past few years several investigators have reported relatively high cesium-137 body burdens in inhabitants of Arctic and subarctic regions, as a result of the deposition of fallout from atmospheric nuclear testing (*1-10*). Cesium-137 has a relatively high yield in nuclear fission and an appreciably long half-life, and behaves much like potassium physiologically. The relatively high body burdens observed in people in northern latitudes (above approximately 56°N) result from a particular ecological chain: lichen to caribou (reindeer) to man. Since cesium-137 is currently one of the principal radionuclides in air and lichen acts as an accumulator of cesium-137, it is likely that the body burdens will continue to be relatively high in Alaskans whose diet includes a substantial amount of caribou meat.

The Division of Radiological Health, Public Health Service, is conducting a continuing surveillance program to determine radioactivity levels in Alaska and to evaluate the health implications.

In addition to a routine program of surveillance of milk, food, and air particulates for radioactivity, cesium-137 body burdens were measured in Alaskans during the spring of 1965 (*11,12*). During April and May 1966, a surveillance team was again sent to Alaska to measure directly the cesium-137 body burdens of the inhabitants. This is a report of the body burdens of Alaskan men observed in the spring of 1966, and a description of the method used.

Selection of counting locations and subjects

To provide geographic coverage of the State, seven PHS Indian Health hospitals, located at Mount Edgecumbe, Anchorage, Kanakanak, Bethel, Kotzebue, Barrow, and Tanana, were selected as counting locations. The Indian Health hospitals served as excellent operating bases because of the availability of subjects, contact with health aides in surrounding villages, and arrangements for local transportation. In addition, counting operations were con-

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[1] The authors are members of the Division of Radiological Health, U.S. Public Health Service. Dr. Fitzpatrick is a member of the research team assigned to the Northeastern Radiological Health Laboratory, Winchester, Massachusetts; Mr. Russell and Mr. Briscoe are assigned to the Technical Development Group, Rockville, Maryland; and Mrs. Calvert, project officer for the Alaskan Study, is assigned to Technical Operations Branch, Washington, D.C. Dr. Fitzpatrick, Mr. Russell, and Mr. Briscoe conducted the counting operations in Alaska and are the investigating team.

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ducted at the St. Anne's Hospital in Juneau, the Bassett Army Hospital at Fort Wainwright in Fairbanks, and at three small villages: Egegik, Anaktuvuk Pass, and Selawik. Anaktuvuk Pass was chosen to provide an operational comparison with data collected by Dr. Wayne Hanson, Battelle-Northwest Laboratory; Selawik and Egegik were chosen because they are areas of high caribou (reindeer) consumption. Figure 1 shows the locations where subjects were counted.

Only adult men were counted because counting geometries were generally more consistent for men than for women or children, and counting accuracy was therefore improved. With the counting technique used, it was not possible to measure potassium–40 body burdens.

The team attempted to locate and count subjects who had been counted by the Division of Radiological Health team in 1965, in order to obtain data on the change in cesium–137 body burdens of these individuals.

Procedure

The cesium–137 body burden counting technique employed in this study was similar to that described by Palmer *(13)* and also similar to the method used by the Division of Radiological Health team in 1965. A 3- by 3-inch NaI (Tl) integral type, hermetically sealed detector, in a special holder designed to hold the thighs together, was placed in the lap of the subject who then bent over the detector and rested his elbows on his knees. A 10-minute count was taken, using a multichannel pulse height analyzer. The system was calibrated using cesium–137 standard sources suitably attached to bags of sugar as a phantom. Since counting efficiency depends on anthropometric factors, phantoms of various weights were constructed and a counting efficiency curve as a function of body weight was determined according to the method of Palmer (*13*).

Each member of the investigating team was counted at both the National Institutes of Health and the National Naval Medical Center, to determine his cesium–137 body burden. In order to provide a suitable background count, a member of the team was counted daily at each location and a ratio was calculated between the cesium–137 portion and a "non cesium–137" portion of the spectrum after the cesium–137 contribution of the team member was subtracted. This ratio was used to correct the spectra of the Alaskan men for background. For body burdens greater than 200 nCi of cesium–137, the results are estimated to be accurate within ±20 percent at the 95 percent confidence level. The uncertainty increased at lower body burdens and was about ±100 percent at 40 nCi. Values reported as less than 40 nCi may have uncertainties greater than the value itself. Averages, however, were calculated using the observed values; all counts that were less than background were taken to be zero.

The problem of peak-shift due to varying magnetic fields, observed during the 1960 counting operation, was solved by the use of magnetic shielding around the phototube and phototube base.

Because the counting rates in the potassium–40 spectral region for the subjects were not significantly different from background, potassium–40 body burdens could not be determined. This problem is inherent in the "lap-counting" method, and makes comparison with other data, which are related to cesium-potassium ratios, difficult.

Each individual was interviewed before counting to obtain information on his diet. The dietary information was used to classify the men into five general categories based on the major meat item of the diet. These categories were caribou (reindeer), fish, marine mammals, game animals, and commercial products. Commercial products were largely imported from the conterminous United States.

Comparison of cesium–137 body burdens in 1966 with those in 1965

Of the 180 men counted in 1965, 49 were recounted in 1966. The cesium–137 body burdens of these, as given in table 1, show a general trend of decreasing body burdens. In five of the seven sampling locations, the average cesium–137 body burden had decreased by 25 to 70 percent over the year. No significant change was found in the body burdens at two locations. Attention is directed to the average values for the 49 men which show that the

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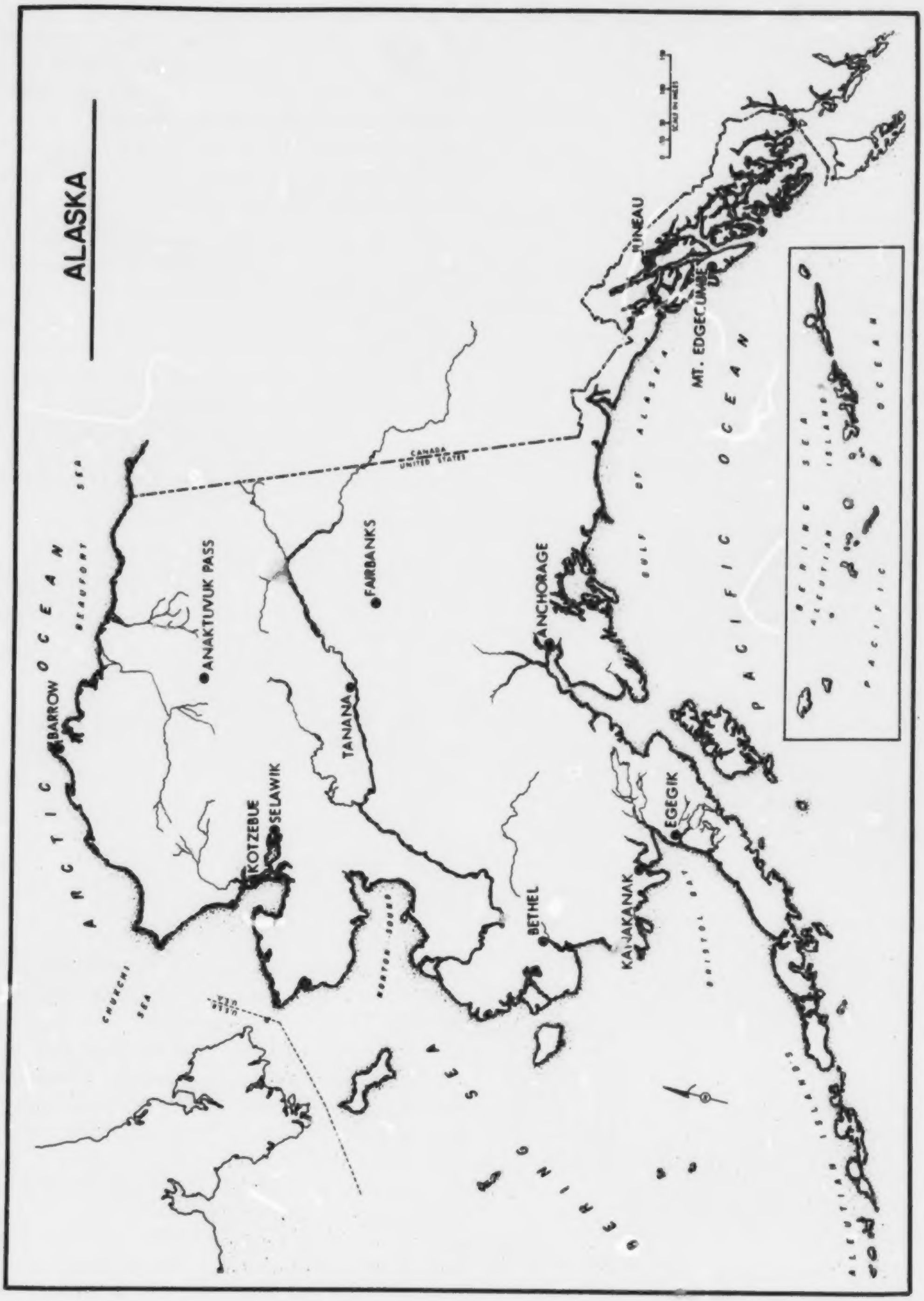
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CANADA
UNITED STATES
ANCHORAGE
JUNEAU
MT. EDGECUMBE
GULF OF ALASKA
PACIFIC OCEAN
NORTON SOUND
BETHEL
KANAKANAK
EGEGIK
BRISTOL BAY
BERING SEA
ALEUTIAN ISLANDS
DATE LINE
BERING SEA
ALEUTIAN ISLANDS
PACIFIC OCEAN

Figure 1. Counting locations for whole body counting surveillance, spring 1966

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average body burden decreased from 280 nCi in 1965 to 140 in 1966, approximately 50 percent.

Table 1. Comparison of cesium-137 body burdens in Alaskan men for 1965 and 1966

Location	Number	Maximum		Arithmetic average	
		1965 (nCi)	1966 (nCi)	1965 (nCi)	1966 (nCi)
Anaktuvuk Pass	2	1,300	460	1,040	380
Anchorage	11	200	160	80	40
Bethel	3	290	80	190	50
Kanakanak (Dillingham)	8	260	350	80	100
Kotzebue	5	760	680	470	360
Mt. Edgecumbe (Sitka)	12	90	60	40	30
Tanana	8	80	160	40	40
All locations	49	1,300	680	280	140

Cesium–137 body burdens of men counted April 25–May 18, 1966

During the 1966 study, the cesium–137 body burdens of 418 Alaskan men were measured. The observations grouped according to counting location are summarized in table 2. Men were counted from over 50 villages and towns and were indigenous to a specific counting location (table 2), except for Anchorage where hospitalized men from the entire State were counted. The body burdens observed in table 2 ranged from 2,400 to less than 40 nCi, with a wide range of values depending on location, which appears to be related to the inclusion of caribou (reindeer) in the diet.

Table 2. Summary of cesium-137 body burdens in Alaskan men, April and May 1966

Counting location	Number	Maximum (nCi)	Minimum (nCi)	Average (nCi)
Anaktuvuk Pass	8	1,040	290	680
Anchorage	70	850	<40	60
Barrow	49	440	<40	160
Bethel	44	200	<40	40
Egegik	29	820	<40	250
Fairbanks	29	190	<40	20
Juneau	31	<40	<40	10
Kanakanak (Dillingham)	28	1,100	<40	120
Kotzebue	28	1,390	<40	240
Mt. Edgecumbe (Sitka)	42	70	<40	20
Selawik	30	2,400	180	1,250
Tanana	30	160	<40	30
All locations	418	2,400	<40	180

During the study, men from areas other than those included in the 1965 study showed high body burdens and led to the transfer of the counting equipment into these areas to count others for a better estimate of these high burdens. Thus, it is noted in table 3 that of the three counting locations having an average body burden of 250 nCi of cesium–137 or more, only Anaktuvuk Pass was tested in 1965, and that the average burden at Selawik was almost twice that at Anaktuvuk Pass.

The effect of caribou (reindeer) meat consumption on the cesium–137 body burden is shown in table 3. The range and average cesium–137 body burdens are given for men who consumed varying amounts of caribou and for men whose major meat item of diet was something other than caribou.

Table 3. Body burdens in Alaskan men as related to meat consumption

Major meat in diet	Number of individuals	Cesium-137, nCi		
		Maximum	Minimum	Average
Caribou/reindeer, by frequency:				
Daily	66	2,400	<40	780
Less than daily	93	1,100	<40	190
Weekly	29	270	<40	80
Monthly	35	290	<40	60
Summary	223	2,400	<40	330
Meat items other than caribou/reindeer:				
Fish	12	60	<40	10
Marine mammals	4	<40	<40	20
Game animals (moose, deer, bear, etc.)	41	120	<40	30
Commercial products	138	150	<40	10
Summary	195	150	<40	15
Total	418	2,400	<40	180

The average cesium–137 body burden was 780 nCi for those who replied they had eaten caribou (reindeer) every day to 60 nCi for those individuals who replied they had eaten caribou only about once a month. Those whose major meat consumption consisted of fish, marine mammals, or game animals (moose, deer, and bear) had a cesium–137 content of 20 to 30 nCi. Those whose major meat consumption consisted of commercial products imported largely from the conterminous United States had a content of 10 nCi. The range and distribution of cesium–137 values in most categories suggested a log-normal distribution.

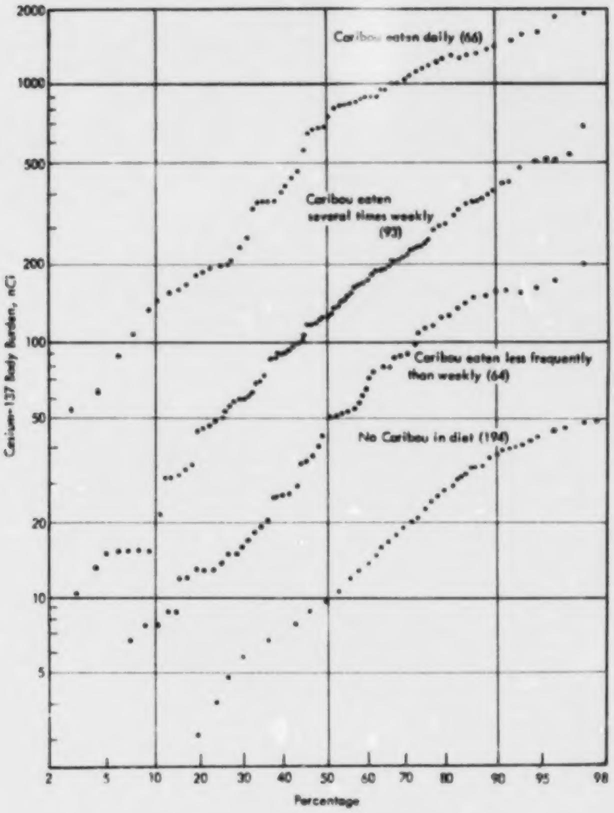

Figure 2. Cumulative frequency distributions of observed cesium-137 body burdens in Alaskan males

Figure 2 illustrates the log-normal distribution of cesium-137 body burden for Alaskan men grouped according to whether or not caribou (reindeer) meat was a part of their diet.

The median burden for those who replied that caribou (reindeer) was part of their diet was 150 nCi cesium-137 as compared to an arithmetic average of 330 nCi, and for those who replied they did not eat caribou (reindeer), the median burden was 10 nCi cesium-137 as compared to an arithmetic average of 15 nCi.

Conclusions

Elevated cesium-137 body burdens are correlated with caribou (reindeer) consumption, and non-caribou eaters exhibit cesium-137 body burdens similar to residents in the conterminous United States. Of the 418 adult males counted during the spring of 1966, none was observed to have a cesium-137 body burden in excess of the guidance of the Federal Radiation Council (3,000 nCi), although one subject was found with a body burden of 80 percent (2,400 nCi) of this level (*14*).

Acknowledgment

The authors are indebted to Sister Mary Angelus, Director of St. Anne's Hospital, Juneau, Alaska; Col. Edwin Lindig, Officer-In-Charge, and Lt. Col. Walter Erne, Executive Officer, Bassett Army Hospital, Ft. Wainwright, Alaska; Dr. Holman Wherritt, Alaskan Area Director, Division of Indian Health, USPHS; and all the Service Unit directors throughout Alaska for providing facilities and for giving their unexcelled cooperation in the conduct of these studies.

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Data

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the United States population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide, however, an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk.

1. Pasteurized Milk Network
August 1966

Division of Radiological Health and
Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this study led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present Pasteurized Milk Network (PMN), which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico (figure 1).

Sampling procedure

Samples are collected through the cooperation of State and local milk sanitation authorities. According to established procedures, the sample at each station is composited of subsamples

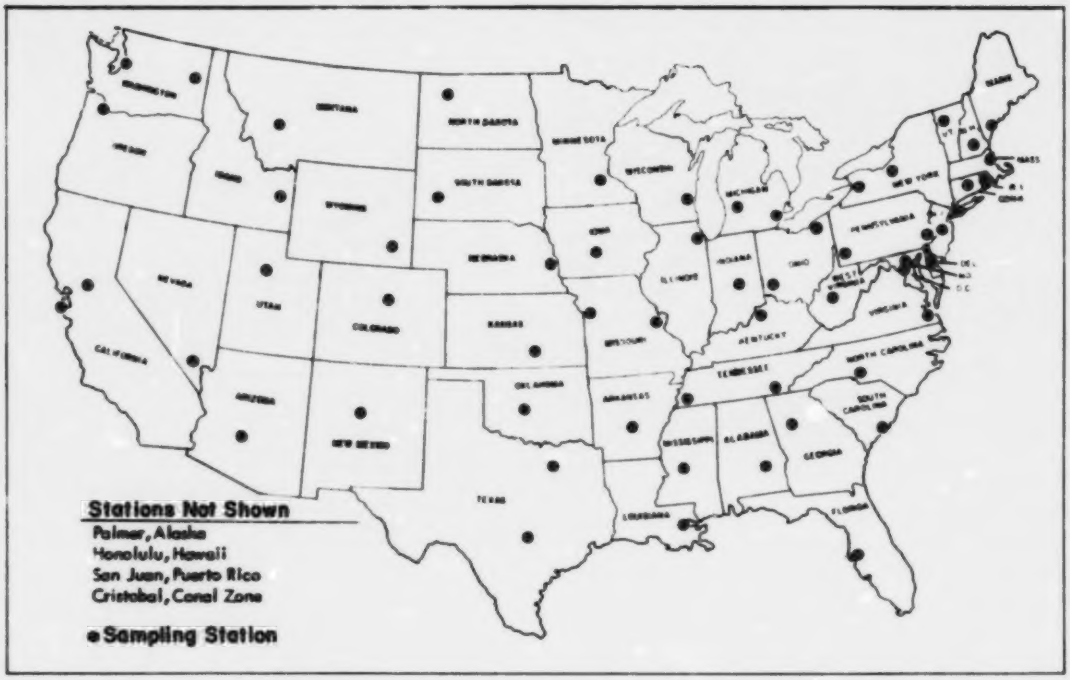

Figure 1. Pasteurized Milk Network sampling locations

from each milk processing plant in proportion to the plant's average sales in the community served. At most stations, the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from 1 day's sales per month and was as representative of the community's supply as was possible under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week, except for the period May 15 through June 25, 1966, when samples were taken twice a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern (NERHL) Radiological Health Laboratories for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pCi/liter are immediately telephoned to appropriate State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after weekly samples are received by the laboratories.

Analytical procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry.[1] After the weekly samples are gamma-scanned, samples from 2 consecutive weeks are composited and analyzed radiochemically to determine strontium–89 and strontium–90. With all such measurements, there is an inherent statistical variation. For the low radionuclide levels usually observed in milk and other environmental samples, this variation on a percentage basis is relatively high. It depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectrometry and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium–89, 5; strontium–90, 2; cesium–137, 10; barium–140, 10; and iodine–131, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used.

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Iodine-131	Less than 100	10	100 or greater	10
Barium-140	Less than 100	10	100 or greater	10
Cesium-137	Less than 100	10	100 or greater	10
Strontium-89	Less than 50	5	50 or greater	10
Strontium-90	Less than 20	2	20 or greater	10

[a] Two standard deviations.

Data presentation

Table 2 presents summaries of the analyses for August 1966. Radionuclide concentrations below the minimum detectable level have been averaged using one-half the minimum detectable value. However, since October 1963, iodine–131 and barium–140 averages have been calculated on the basis of zero when concentrations below the minimum detectable level were observed. A similar procedure is used for the network average.

The distribution of monthly average strontium–90 and cesium–137 concentrations as observed in pasteurized milk for the months August 1965 and March through August 1966 are presented in tables 3 and 4. The average monthly strontium–90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 2.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

Table 2. Average concentrations of radionuclides in pasteurized milk for the second quarter and August 1966 [a]

Sampling locations		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)		Barium-140 (pCi/liter)	
		Second quarter [b]	August 1966	Second quarter	August 1966	Second quarter	August 1966	Second quarter	August 1966	Second quarter	August 1966
Ala:	Montgomery		<5	12	11	25	20	10	0	0	0
Alaska:	Palmer		<5	15	12	40	35	0	0	0	0
Ariz:	Phoenix		<5	3	3	10	15	0	0	0	0
Ark:	Little Rock		<5	32	24	40	25	40	0	10	0
Calif:	Sacramento		<5	9	5	15	10	0	0	0	0
	San Francisco		<5	9	4	20	15	0	0	0	0
C. Z:	Cristobal		<5	4	4	20	20	0	0	0	0
Colo:	Denver		<5	11	7	25	20	0	0	0	0
Conn:	Hartford		<5	13	11	40	30	0	0	0	0
Del:	Wilmington		<5	17	12	40	20	0	0	0	0
D.C:	Washington		<5	13	12	30	20	0	0	0	0
Fla:	Tampa		<5	10	11	125	145	0	0	0	0
Ga:	Atlanta		5	20	20	40	30	10	0	0	0
Hawaii:	Honolulu		<5	6	5	30	20	0	0	0	0
Idaho:	Idaho Falls		<5	14	15	40	20	0	0	0	0
Ill:	Chicago		<5	13	8	35	15	0	0	0	0
Ind:	Indianapolis		5	13	12	30	15	20	0	0	0
Iowa:	Des Moines		<5	16	12	30	15	10	0	0	0
Kans:	Wichita		<5	14	10	20	10	20	0	0	0
Ky:	Louisville		<5	19	15	20	10	0	0	0	0
La:	New Orleans		<5	32	33	45	65	0	0	0	0
Maine:	Portland		<5	16	13	70	50	0	0	0	0
Md:	Baltimore		<5	15	12	30	20	0	0	0	0
Mass:	Boston		<5	17	16	60	50	0	0	0	0
Mich:	Detroit		<5	12	8	30	20	0	0	0	0
	Grand Rapids		<5	16	11	45	25	0	0	0	0
Minn:	Minneapolis		<5	23	15	40	30	0	0	0	0
Miss:	Jackson		<5	26	20	30	25	10	0	0	0
Mo:	Kansas City		<5	17	12	25	10	30	0	0	0
	St. Louis		10	19	14	30	20	30	0	0	0
Mont:	Helena		<5	14	10	55	30	0	0	0	0
Nebr:	Omaha		<5	15	11	30	20	10	0	0	0
Nev:	Las Vegas		<5	6	4	25	10	0	0	0	0
N.H:	Manchester		<5	17	17	80	75	0	0	0	0
N.J:	Trenton		<5	13	11	30	20	0	0	0	0
N. Mex:	Albuquerque		<5	6	7	20	15	0	0	0	0
N.Y:	Buffalo		<5	12	10	40	25	0	0	0	0
	New York		<5	15	15	40	35	0	0	0	0
	Syracuse		<5	13	10	40	25	0	0	0	0
N.C:	Charlotte		<5	20	20	30	25	20	0	0	0
N. Dak:	Minot		<5	34	22	40	30	0	0	0	0
Ohio:	Cincinnati		<5	15	10	25	15	0	0	0	0
	Cleveland		<5	14	11	35	15	0	0	0	0
Okla:	Oklahoma City		<5	14	12	20	15	20	0	0	0
Ore:	Portland		<5	14	11	40	30	0	0	0	0
Pa:	Philadelphia		<5	14	12	35	20	0	0	0	0
	Pittsburgh		<5	19	15	45	30	0	0	0	0
P.R:	San Juan		<5	8	7	25	25	0	0	0	0
R.I:	Providence		<5	15	16	45	40	0	0	0	0
S.C:	Charleston		<5	21	20	50	50	20	0	0	0
S. Dak:	Rapid City		5	21	13	45	15	0	0	0	0
Tenn:	Chattanooga		<5	21	20	30	25	0	0	0	0
	Memphis		<5	19	16	20	10	20	0	0	0
Tex:	Austin		<5	6	5	15	10	0	0	0	0
	Dallas		<5	16	11	25	15	20	0	0	0
Utah:	Salt Lake City		<5	12	9	35	15	0	0	0	0
Vt:	Burlington		<5	14	13	50	35	0	0	0	0
Va:	Norfolk		<5	16	16	30	20	0	0	0	0
Wash:	Seattle		<5	18	17	55	50	0	0	0	0
	Spokane		<5	18	11	40	30	0	0	0	0
W. Va:	Charleston		<5	17	14	20	15	0	0	0	0
Wis:	Milwaukee		<5	10	8	40	20	0	0	0	0
Wyo:	Laramie		<5	12	8	30	15	0	0	0	0
Network average			<5	15.2	12.4	36	26	5	0	0	0

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[a] Calcium analyses were discontinued as of March 1966.

[b] Quarterly averages are not reported since monthly averages for April were not calculated as only 10 percent of the samples were analyzed for strontium-89.

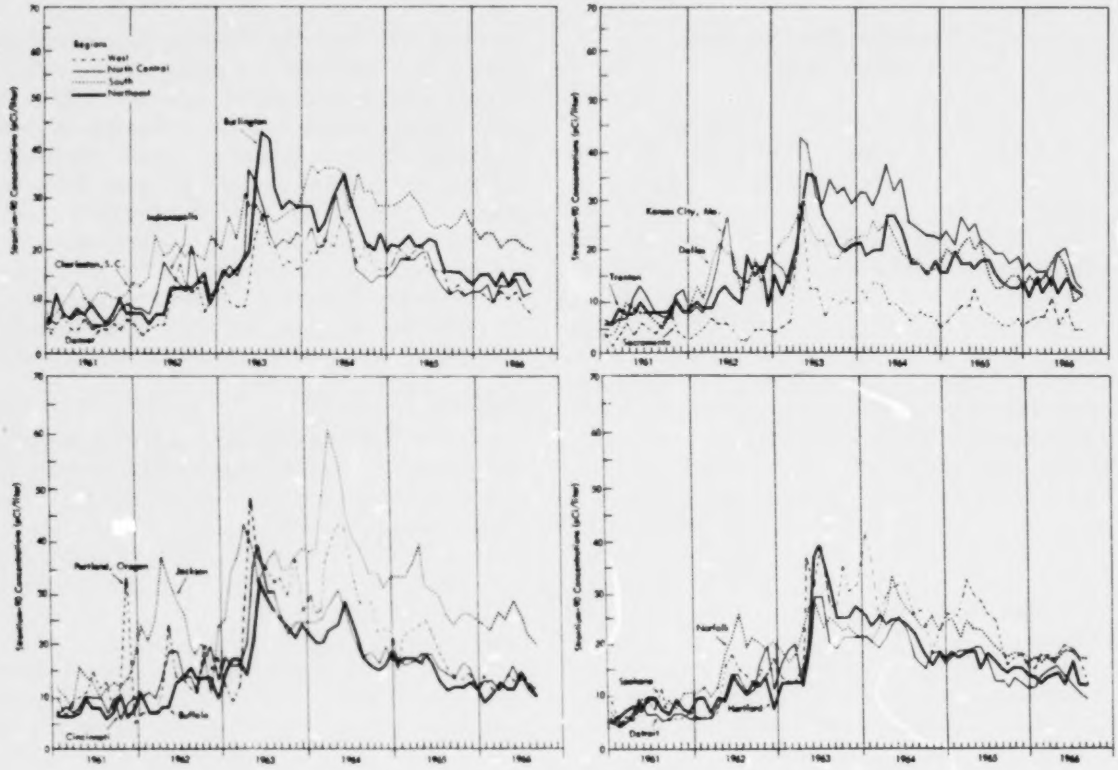

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961–August 1966

Table 3. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, August 1965 and March–August 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965	1966					
	Aug	Mar	Apr	May	June	July	Aug
Under 10	10	9	8	10	9	14	15
10–19	41	44	50	38	41	39	40
20–29	11	7	3	12	10	9	7
30–39	1	3	2	3	3	1	1

Table 4. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, August 1965 and March–August 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965	1966					
	Aug	Mar	Apr	May	June	July	Aug
Under 50	45	56	55	51	56	56	56
50–99	16	6	7	11	6	6	6
100–149	1	1	1	1	1	1	1
150–199	1	0	0	0	0	0	0

2. Canadian Milk Network
August 1966[2]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. In the beginning, analyses were carried out on samples of powdered milk obtained from processing plants. In January 1963, analysis of liquid whole milk was begun. This change allowed more representative samples of milk consumed to be obtained, and allowed the milk sampling locations (figure 3) to be chosen in the same areas as the air and precipitation stations. At present, the analyses include determinations of cesium-137 and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 are not reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, cesium-137, and stable potassium and calcium.

Analytical methods

Since it represents a more sensitive method, radiochemistry, rather than gamma spectrometry, is used to determine iodine-131 (*2*). For the analysis of radiostrontium, carrier strontium is added to a 1-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infrared lamps. The residue is ashed in a muffle furnace at 450°C. and dissolved in dilute nitric acid; strontium is separated by fuming nitric acid precipitation. The combined strontium-89 and strontium-90 are determined by counting in a low-background beta counter. Strontium-90 is determined separately by extracting and counting its yttrium-90 daughter, while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption

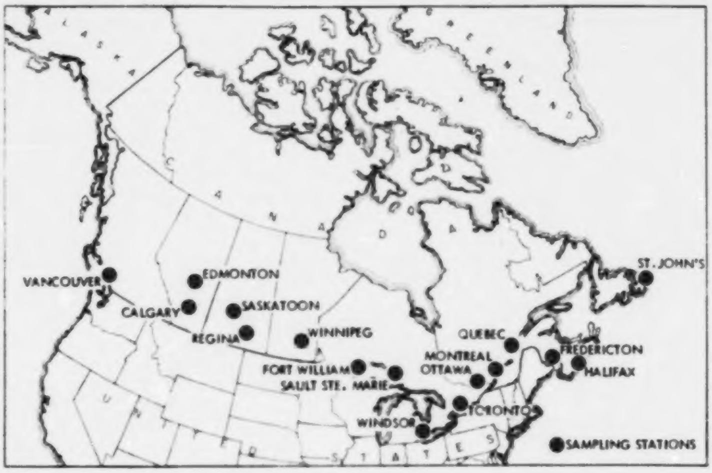

Figure 3. Canadian milk sampling stations

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[2] Prepared from information and data in the September 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

and counter-efficiency at all stages. Calcium is determined by flame photometry.

Cesium-137 is determined by gamma-scintillation spectrometry using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5- by 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum is then recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium-40 concentration is determined and the Compton contribution of this radionuclide to the cesium-137 photopeak is subtracted to obtain the cesium-137 concentration. The stable potassium content is estimated from the potassium-40 concentration.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is approximately plus-or-minus 10 percent. This value is independent of the concentration of the radionuclide in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error, which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 5.

Table 5. Total error for various radionuclide concentrations in milk [a]

Nuclide	Error for 10 pCi/liter	Error for 50 pCi/liter	Error for 100 pCi/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±20%	±10%

[a] All errors are 2 σ values, representing 95-percent confidence levels.

Results

Table 6 presents monthly averages of strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 and strontium-89 indicate that all samples had insignificant levels of these radionuclides.

The results show that radionuclide concentrations in Canadian whole milk remained well below the permissible levels.

Table 6. Radionuclides in Canadian whole milk August 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.11	1.4	12.8	28
Edmonton	1.10	1.5	14.6	47
Ft. William	1.04	1.6	18.2	68
Fredericton	1.07	1.5	24.6	54
Halifax	1.13	1.5	20.6	49
Montreal	1.08	1.5	12.7	32
Ottawa	1.12	1.5	10.0	28
Quebec	1.01	1.6	15.8	49
Regina	1.08	1.4	14.3	27
St. John's, Nfld	1.06	1.5	41.1	134
Saskatoon	1.14	1.5	13.8	27
Sault Ste. Marie	1.07	1.5	18.1	51
Toronto	1.09	1.6	7.2	24
Vancouver	1.17	1.5	21.2	81
Windsor	1.08	1.5	4.7	20
Winnipeg	1.06	1.5	12.1	28
Average	1.09	1.5	16.4	47

3. Pan American Milk Sampling Program August 1966

Pan American Health Organization and U.S. Public Health Service

In accordance with a joint agreement, the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) developed a collaborative program for furnishing assistance to health authorities in the Americas engaged in developing programs in radiological health.

Under this agreement, the PHS Division of Radiological Health furnishes to PAHO, on a loan basis, limited quantities of essential items of equipment and the requisite laboratory services to establish a surveillance program.

Sampling procedure

Initially, air sampling stations were established in Jamaica and Venezuela. In August 1963, the milk sampling program was begun with a milk sampling station in Caracas, Venezuela. Between April 1964 and August 1964, milk stations were added in Jamaica at Kingston, Montego Bay, and Mandeville. In July 1966, a station was added at Guayaquil, Ecuador (figure 4). Sampling varies according to local procedures.

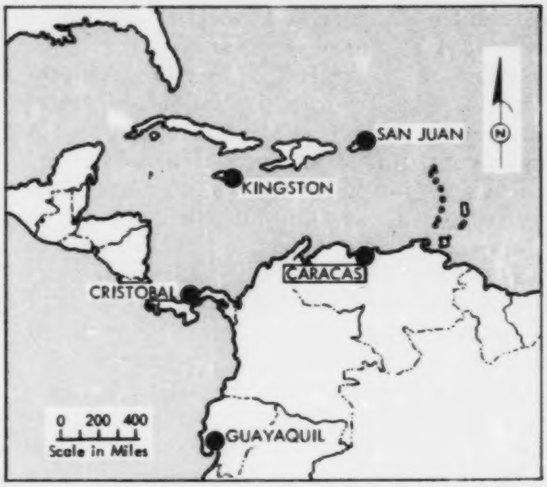

Figure 4. Pan American Milk Sampling Program stations

Under the direction of the Venezuelan Institute for Scientific Investigation, weekly samples are collected, preserved with formaldehyde, and composited monthly.

Jamaica, under the direction of the Ministry of Health, collects one monthly composite on a rotating basis from one of the three principal milk areas: Montego Bay (Montpelier), Mandeville, and Kingston (Spanish Town). All samples are sent to the PHS Southeastern Radiological Health Laboratory for analysis.

Table 7. Stable element and radionuclide concentrations in PAHO milk August 1966[b]

Sampling station		Number of samples	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)	Barium-140 (pCi/liter)
Chile:	Santiago	1	1.04	1.60	10	5	<10
Colombia:	Bogota	4	1.08	1.51	3	5	<10
Ecuador:	Guayaquil	3	1.02	1.62	3	<5	<10
Jamaica:	Kingston[a]	1	1.20	1.39	13	205	<10
	Mandeville	1	1.08	1.32	8	140	10
	Montego Bay	NS	NS	NS	NS	NS	NS
Venezuela:	Caracas	1	1.11	1.32	4	5	<10
Canal Zone:	Cristobal		—	—	4	20	—
Puerto Rico:	San Juan		—	—	7	25	—

[a] Data from April 1966.
[b] Iodine-131 concentrations were less than 10 pCi/liter and strontium-89 concentrations were less than 5 pCi/liter for all samples.
NS, no sample collected.

Analytical procedures

Iodine–131 and cesium–137 are determined by gamma-scintillation spectrometry. Strontium–89, strontium–90, and barium–140 are determined radiochemically (*3*). Analytical errors are discussed in the "Analytical procedures, Pasteurized Milk Network."

Data presentation

Table 7 presents stable calcium and potassium, strontium–89, strontium–90, and cesium–137 monthly average concentrations. The monthly average of iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Summary of results for raw milk sampling program, June 1957 to April 1963. Radiol Health Data 4:511–523 (October 1963).

(*2*) DASGUPTA, A. K., and H. G. GREEN. A method for the radiochemical determination of iodine–131 in milk, RPD–23. Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

(*3*) PORTER, C., and B. KAHN. Improved determinations of strontium–90 in milk by an ion-exchange method. Anal Chem 36:676–678 (March 1964).

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed to a state of comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	*Period reported*	*Last presented*
Colorado	May 1965–June 1966	October 1966
Connecticut	April–June 1966	November 1966
Florida	April–June 1966	October 1966
Indiana	April–June 1966	November 1966
Michigan	January–June 1966	November 1966
Minnesota	April–June 1966	November 1966
New York	January–June 1966	November 1966
Oklahoma	April–June 1966	October 1966
Pennsylvania	April–June 1966	November 1966
Texas	April–June 1966	October 1966

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1. California Milk Network

April–June 1966

Division of Environmental Sanitation
Department of Public Health
State of California

Surveillance of specific radionuclides in milk is one phase of the California Department of Health program on radiation control. This milk-monitoring function has been conducted at eight milksheds since January 1960 by the Department's Bureau of Radiological Health. With the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (figure 1). The original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

Strontium–89 and strontium–90 concentrations are determined radiochemically. Potassium–40, iodine–131, cesium–137, and barium–140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented earlier (*2*).

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period April to June 1966.

Network average strontium–90 and cesium–137 concentrations are presented graphically in figure 2.

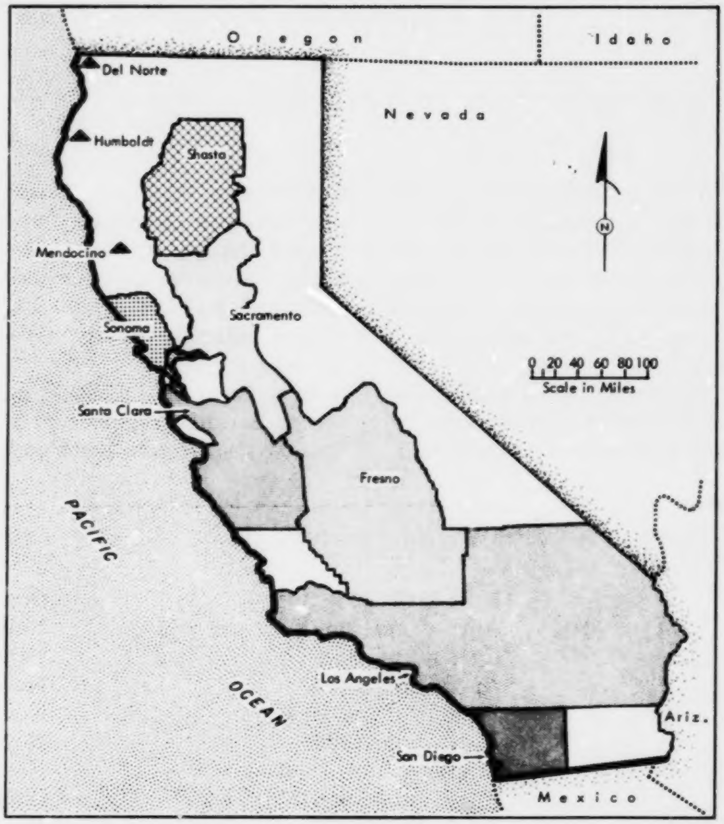
Oregon
Idaho
Del Norte
Nevada
Humboldt
Shasta
N
Mendocino
Sacramento
Sonoma
0 20 40 60 80 100
Scale in Miles
Santa Clara
Fresno
PACIFIC
OCEAN
Los Angeles
Ariz.
San Diego
Mexico

Figure 1. California milksheds

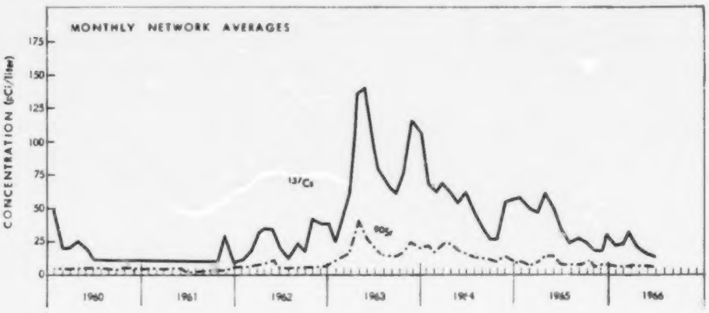

Figure 2. Radionuclide concentrations in California milk
January 1960–June 1966

Table 1. Stable elements and radionuclides in California milk, April–June 1966

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium, g/liter											
April	1.23	1.20	1.19	1.05	1.20	1.17	1.12	1.16	1.13	1.20	1.16
May	1.34	1.14	1.25	1.03	1.14	1.18	1.10	1.01	1.08	1.17	1.14
June	1.38	1.12	1.25	1.12	1.10	1.20	1.05	1.18	1.13	1.19	1.17
Potassium-40, pCi/liter											
April	1,200	1,190	1,130	1,360	1,240	1,160	1,260	1,190	1,210	1,250	1,230
May	1,200	1,210	1,160	1,330	1,220	1,270	1,200	1,310	1,200	1,230	1,230
June	1,180	1,240	1,160	1,280	1,260	1,270	1,210	1,340	1,240	1,300	1,250
Strontium-89, pCi/liter											
April	ND	NA	NA	NA	NA	NA	NA	ND	ND	NA	ND
May	ND	NA	ND	ND	ND	NA	NA	ND	0.6	NA	<0.1
June	15.0	ND	11.0	ND	4.2	0.9	<0.1	ND	2.0	1.5	3.5
Strontium-90, pCi/liter											
April	26.0	3.4	1.2	3.8	8.3	5.6	3.1	3.7	8.0	8.7	7.2
May	28.0	3.3	9.0	3.6	6.2	4.7	2.7	2.9	6.5	8.8	7.6
June	23.0	4.2	9.3	3.3	5.0	1.3	5.4	2.8	6.6	4.5	6.5
Cesium-137, pCi/liter											
April	45	13	21	12	15	17	[a] 7	11	19	17	18
May	40	13	15	12	[a] 7	10	16	15	12	12	15
June	37	13	16	[a] 9	ND	[a] 9	[a] 5	[a] 5	15	11	12

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant. Where no value is given, no activity was detected.
ND, not detectable
NA, no analysis performed

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
July–September 1963	March 1964
October–December 1963	June 1964
Annual summary 1964	June 1966
Annual summary 1965	June 1966
January–March 1966	September 1966

2. Oregon Milk Network
April–June 1966

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program routine, milk samples are collected at eight major production areas (figure 3), which supply 90 percent of the milk distributed in Oregon. Currently, pasteurized milk samples are collected monthly by the Oregon Department of Agriculture, except in the Portland area, where weekly samples are collected by the city of Portland. The milk sampling frequency is accelerated to a weekly basis in areas where iodine-131 concentrations exceed 100 pCi/liter, or where cesium-137 concentrations exceed 500 pCi/liter. Strontium-90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium-90 concentrations are determined using a trichloroacetic acid analytical procedure (*3*). Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry (*4*).

Table 2 gives the strontium-90 and cesium-137 concentrations in pasteurized milk from April through June 1966. These data are presented graphically in figure 4. Iodine-131 and barium-140 concentrations remained below minimum detectable levels of 15 pCi/liter.

Table 2. Radionuclide concentrations in Oregon milk, April–June 1966

Sampling location	Sampling frequency	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
		April	May	June	April	May	June
Baker	M	NS	10	NS	30	25	20
Coos Bay	M	NA	22	NS	90	40	45
Eugene	M	NA	10	NS	35	40	40
Medford	M	NS	6	NS	70	20	65
Nyssa	M	NS	7	NS	30	35	15
Portland composite	W	14	12	15	47	26	36
Portland local	W	NA	18	NA	51	53	43
Redmond	M	NA	9	NS	40	40	30
Tillamook	M	NA	28	NS	55	85	55
Average		14	14	15	50	38	38

M, sampled monthly
W, sampled weekly
NS, no sample collected
NA, no analysis

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1964 and summary 1962–1964	June 1965
Annual summary 1965	June 1966
January–March 1966	September 1966

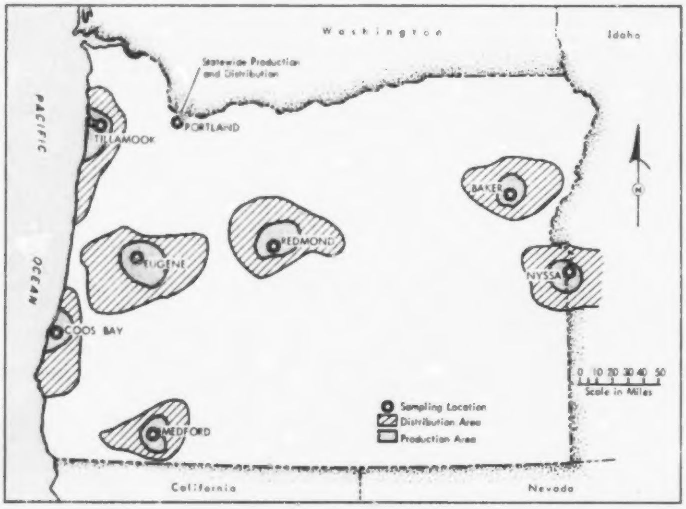
Washington
Idaho
Statewide Production and Distribution
PORTLAND
TILLAMOOK
PACIFIC
OCEAN
BAKER
REDMOND
EUGENE
NYSSA
COOS BAY
MEDFORD
N
0 10 20 30 40 50
Scale in Miles
Sampling Location
Distribution Area
Production Area
California
Nevada

Figure 3. Oregon milk production and distribution areas

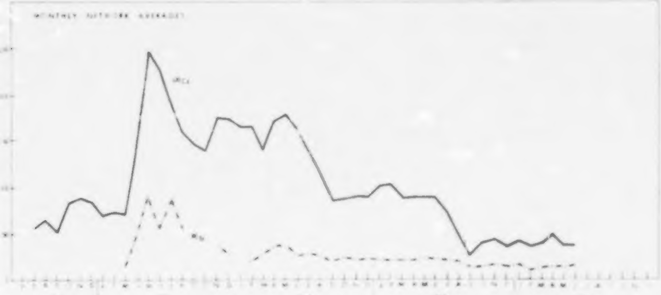

Figure 4. Radionuclide concentrations in Oregon milk network June 1962–June 1966

3. Washington Milk Network April–June 1966

Air Sanitation and Radiation Control Section
State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 5 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint) as this area forms a part of the Spokane milkshed. Details of the sampling procedures were presented earlier (*5*).

Selected samples are analyzed radiochemically for strontium–90. Potassium–40, iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for April through June 1966. During this period, iodine-131 and barium-140 concentrations remained below minimum detectable levels. Monthly average strontium–90 and cesium–137 concentrations are presented graphically in figure 6, so as to display general trends.

Zinc–65 in the Benton-Franklin area remained below minimum detectable levels during this period. This nuclide has periodically appeared in this area as a result of the irrigation

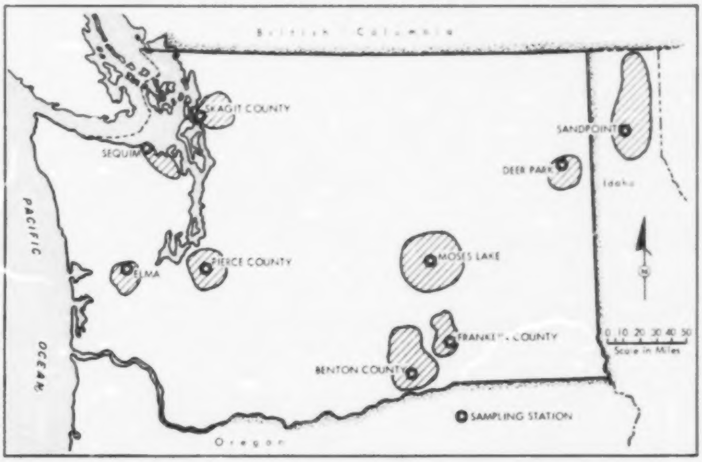
British Columbia
SKAGIT COUNTY
SANDPOINT
SEQUIM
DEER PARK
Idaho
PACIFIC OCEAN
ELMA
PIERCE COUNTY
MOSES LAKE
FRANKLIN COUNTY
BENTON COUNTY
0 10 20 30 40 50
Scale in Miles
SAMPLING STATION
Oregon

Figure 5. Washington milksheds and sampling locations

of some pasture land with Columbia River water which has been shown to contain this radionuclide.

Table 3. Radionuclide concentrations in Washington milk, April–June 1966

Sampling location	April	May	June
	Potassium-40, pCi/liter		
Benton county	1,050	NS	1,250
Deer Park	1,190	1,210	1,260
Elma	1,120	1,170	1,260
Franklin County	NS	NS	NS
Moses Lake	1,210	1,320	1,210
Pierce County	1,260	1,170	1,170
Sandpoint	1,190	1,270	1,250
Sequim	1,140	1,180	NS
Skagit County	1,180	1,130	1,280
Average	1,170	1,210	1,240
	Strontium-90, pCi/liter		
Benton County	6	NS	6
Deer Park	11	13	13
Elma	11	14	20
Franklin County	NS	NS	NS
Moses Lake	7	7	7
Pierce County	8	11	15
Sandpoint	32	32	26
Sequim	11	14	NS
Skagit County	17	20	18
Average	13	16	15
	Cesium-137, pCi/liter		
Benton County	33	NS	25
Deer Park	42	45	43
Elma	44	63	37
Franklin County	NS	NS	NS
Moses Lake	21	17	19
Pierce County	33	46	74
Sandpoint	85	84	98
Sequim	52	63	NS
Skagit	63	54	54
Average	47	53	50

NS, no sample collected.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
December 1962–December 1963	May 1964
Annual summaries 1964 and 1965	June 1966
January–March 1966	September 1966

REFERENCES

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(2) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1960–June 1962. Radiol Health Data 4:90–92 (February 1963).

(3) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium-90 determinations in milk. J Dairy Sci 43:151–154 (1960).

(4) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April–June 1965. Radiol Health Data 6:683–684 (December 1965).

(5) STATE OF WASHINGTON DEPARTMENT OF HEALTH, AIR AND RADIATION CONTROL SECTION, Washington milk network, January–June 1965. Radiol Health Data 6:619–621 (November 1965).

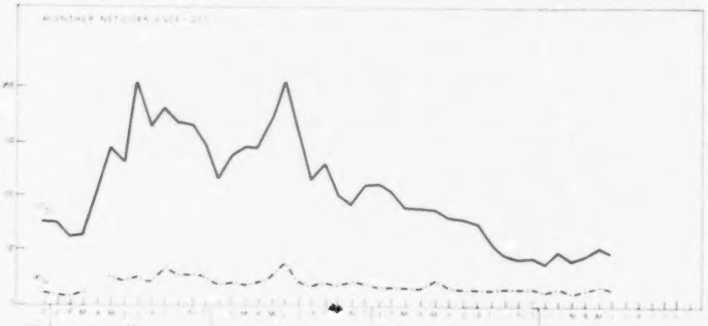

Figure 6. Radionuclide concentrations in Washington milk 1962–June 1966

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Also included in this issue are results for the United Kingdom Diet Survey, 1965, from the United Kingdom Agricultural Research Council Radiobiological Laboratory. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are listed below:

Program	Period reported	Last presented
California Diet	September–December 1965	September 1966
Connecticut Standard Diet	July 1965–June 1966	November 1966
Institutional Diet, PHS	January–March 1966	October 1966
Teenage Diet, FDA	February–November 1965	August 1966

1. Radionuclides in United Kingdom Diet 1965

Radiobiological Laboratory
United Kingdom Agricultural Research Council

Surveys of strontium–90 and cesium–137 in foodstuffs consumed in the United Kingdom, which have been described in previous reports in this series (*1,2*), were continued in 1965. Because it was apparent from the survey of radioactivity in milk that dietary levels would be lower in 1965 than in 1964, measurements were no longer made of some minor sources of contamination. Details of sampling procedures and full results for 1965 are given in the laboratory's latest report (*3*).

Content of strontium–90 in the average diet

The mean quantity of strontium–90 in the average mixed diet of the population in the United Kingdom has been calculated by multiplying the mean ratio of strontium–90 to calcium in different types of food by the quantities of calcium they contribute to the diet. The values for 1965 are given in table 1; they are compared in table 2 with results for previous years which were calculated in a similar manner.

The contamination of diet decreased during 1965; the average ratio of strontium–90 to calcium in the mixed diet during the year was 17.9 pCi/g, or about two-thirds of the value in 1964. The relative contributions of various kinds of foods to the total intake of strontium–90 differed little from those in previous years, dairy produce accounting for about 60 percent of the total. The mean ratio of strontium–90 to calcium in milk during 1965 was 1.06 times that in the mixed diet. This is very close to the average for the previous 7 years, when the values ranged from 0.95 to 1.2, and confirms the validity of inferring levels of dietary contamination in the United Kingdom from the results of measurements on milk. The significance of variations in the consumption of individual items of diet, or in their origin, is discussed in an earlier report (*2*).

Cesium-137 in milk and meat

It has been explained previously (*2*) that the radiation dose to man caused by cesium-137 in diet is best assessed from whole-body measurements and that dietary surveys are to be regarded only as supplementary. Results from past years have shown that milk and meat are the principal sources of cesium-137 in diet, together accounting for about 60 to 80 percent of the total intake; in 1965, therefore, measurements of cesium-137 were made only on these two foodstuffs.

The countrywide average concentration of cesium-137 in milk, weighted according to production in the different areas, was 98 pCi/liter in 1965, which is about one third lower than the value in the previous year. The mean level of cesium-137 in home-produced and imported meat consumed in the United Kingdom during 1965 was about 280 pCi/kg compared with 490 pCi/kg in 1964. It may be inferred therefore, that the total dietary intake of cesium-137 during 1965 was also about one third lower than in 1964.

Table 1. Mean content of strontium-90 in the diet in the United Kingdom, 1965

Origin	Mean daily intake of calcium [a] (mg)	Mean ratio ^{90}Sr/Ca (pCi/g)	Estimated daily intake of ^{90}Sr (pCi)
Dairy produce:			
Milk and cream	515	19.0	9.78
Cheese	104	21.1	2.19
Vegetables and fruit:			
Root vegetables	25	55.9	1.40
Leaf and other vegetables	36	26.3	0.95
Fruit, etc	17	26.3	0.45
Flour and cereals	[b] 244	11.6	2.83
Meat	23	38.0	0.87
Other sources:			
Drinking water	60	—	0.95
Miscellaneous	60	—	—
Total mixed diet	1,084	17.9	19.42

[a] Values computed by the Ministry of Agriculture, Fisheries, and Food from surveys of domestic food consumption. The values differ slightly from those used to calculate the daily intake in previous years.

[b] This includes about 201 mg mineral calcium added to flour as *creta praeparata*.

Table 2. Comparison of levels of strontium-90 in the United Kingdom diet, 1958–1965

Food item	1958	1959	1960	1961	1962	1963	1964	1965
	Mean ^{90}Sr/Ca ratio, pCi/g							
Total diet (including drinking water and tea) [a]	5.9	9.0	6.4	6.2	9.9	22.8	25.9	17.9
Milk and cream	7.0	9.8	6.4	5.9	11.7	25.6	28.0	19.0
Cheese	7.7	7.5	5.3	4.8	8.7	19.7	24.7	21.1
Root vegetables	14.2	23.2	19.6	24.3	25.1	53.1	48.4	55.9
Leaf vegetables and fruit	8.7	14.3	8.5	10.3	17.6	35.4	30.6	26.3
Flour and cereals	15.9	28.0	22.7	21.8	18.4	71.9	[b] 17.4	[b] 11.6
Eggs	....	9.0	6.3	....	6.2	12.0	27.6	....
	Intake of strontium-90, pCi/day							
Total diet	6.4	9.8	6.9	6.7	10.7	24.7	28.5	19.4
	Percentage of total [c]							
Milk and cream	54.3	49.7	45.7	43.7	54.2	51.4	52.0	50.4
Cheese	11.4	7.3	7.2	6.9	7.7	7.6	9.0	11.3
Root vegetables	5.5	5.9	7.1	9.1	5.9	5.4	4.2	7.2
Leaf vegetables and fruit	8.5	9.0	7.5	9.5	10.2	8.9	5.7	7.2
Flour and cereals	11.7	13.5	15.4	15.2	8.0	13.7	15.1	14.6
Other foodstuffs	5.0	5.6	5.3	5.2	5.3	4.9	6.3	4.5
Drinking water	3.6	4.4	5.2	3.7	3.8	3.4	3.7	4.9
Tea	....	4.6	6.5	6.7	4.9	4.7	3.9	....

[a] Account has been taken of mineral calcium (*creta praeparata*) added to flour.

[b] In contrast to previous years, the values for 1964 and 1965 are based on the analysis of flour to which mineral calcium as *creta praeparata* had been added. The values for these 2 years comparable with those for previous years, when only the natural calcium was present in the samples analyzed, would be about 100 pCi/g and 70 pCi/g, respectively.

[c] Tea was not sampled in 1958 and 1965, so the percentages for these years are not strictly comparable with the others.

2. Strontium-90 in Tri-City Diets February–April 1966 [1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, U.S. Atomic Energy Commission, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these 3 cities every 3 months on a staggered basis (that is, New York City, February 1966; San Francisco, March 1966; and Chicago, April 1966) and are analyzed for strontium-90. Fourteen of the diet categories are analyzed on a quarterly basis. Eggs, poultry, fresh fish, shellfish, and meat are purchased quarterly, but analyzed annually. This policy was initiated in 1965 due to the lower concentrations of strontium-90 in these food categories. The contribution of these five diet categories to the total annual intake of strontium-90 over the last 4 years has been approximately 5 percent. Therefore, this figure is used to calculate their contribution to the total strontium-90 dietary intake. These values are added to contributions of the other 14 food categories to obtain quarterly estimates of annual strontium-90 intake at the 3 cities. Consumption figures used are based upon data from the Department of Agriculture (*4*).

Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city, it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*5*). Calcium analyses were therefore discontinued and the average calcium content of foods was computed and used to estimate the average annual intake of this material. Details of the sampling system and a discussion of the results obtained have been summarized (*6*).

Results of the February to April 1966 sampling are presented in table 3. The variation

Table 3. Average dietary consumption and strontium-90 intake in Tri-City diet, February–April 1966

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City February 1966		San Francisco March 1966		Chicago April 1966	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Bakery products	37	37.0	16.9±1.0	625	10.8±0.9	400	12.6±0.9	466
Whole grain products	11	10.0	33.9±1.6	373	23.5±1.1	259	18.3±1.0	201
Fresh vegetables	43	15.0	12.5±0.4	538	2.5±0.2	108	12.8±0.3	550
Root vegetables	17	6.1	10.2±0.3	173	14.5±0.5	247	8.8±0.4	150
Milk	221	234.4	13.2±0.7	2,917	7.2±0.4	1,591	11.1±0.4	2,453
Flour	43	8.6	18.0±0.4	774	7.1±0.3	305	16.3±0.6	701
Macaroni	3	0.7	8.9±0.4	27	8.8±0.3	26	11.3±0.4	34
Rice	3	1.1	2.3±0.4	7	1.6±0.3	5	2.4±0.2	7
Dried beans	3	2.9	21.5±1.7	65	19.7±1.5	59	24.7±1.6	74
Fresh fruit	68	12.6	2.7±0.3	184	2.2±0.2	150	4.4±0.3	299
Potatoes	45	5.8	11.8±0.6	531	3.0±0.3	135	6.6±0.4	297
Canned fruit	26	1.3	1.9±0.1	49	1.6±0.1	42	1.8±0.2	47
Fruit juices	19	1.7	9.5±0.4	371	2.0±0.2	38	4.1±0.3	78
Canned vegetables	20	4.2	12.4±1.0	248	2.6±0.3	52	8.5±0.4	170
Meat, fish, poultry, shellfish, and eggs	99	42.0		• 362		• 180		• 291
Annual intake		383		7,244		3,597		5,818
Daily intake		1.05		19.8		9.9		15.9
pCi strontium-90/g Ca				18.9		9.4		15.2

• Estimated as 5 percent of total intake.

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[1] Data from Fallout Program Quarterly Summary Report, HASL-173. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151.

with time of the daily intake of strontium-90 in the three cities is plotted in figure 1. A discussion of cesium-137 intakes as reflected in the Tri-City Diet Study was presented elsewhere (*7*).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Sixteenth sampling (February 1964–April 1964)	December 1964
Seventeenth sampling (July–September 1964)	March 1965
Eighteenth sampling (August–October 1964)	June 1965
Nineteenth sampling (November 1964–January 1965)	September 1965
Twentieth sampling (February–April 1965)	December 1965
Twenty-first sampling (May–July 1965)	March 1966
Twenty-second sampling (August–October 1965)	June 1966
Twenty-third sampling (November 1965–January 1966)	September 1966

REFERENCES

(*1*) AGRICULTURAL RESEARCH COUNCIL RADIOBIOLOGICAL LABORATORY. Strontium-90 in diet in the United Kingdom, 1958–1961. Radiol Health Data 4:134–137 (March 1963).

(*2*) BRUCE, R. S. Radionuclides in the United Kingdom Diet, 1962–1964. Radiol Health Data Rep 7: 331–334 (June 1966).

(*3*) AGRICULTURAL RESEARCH COUNCIL RADIOBIOLOGICAL LABORATORY. Report ARCRL 16 (1966).

(*4*) U. S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, 1955, Report No. 1. Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (December 1956).

(*5*) U. S. ATOMIC ENERGY COMMISSION. Fallout program quarterly summary report HASL-144:281–287. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (April 1, 1964). Summarized in Radiol Health Data 5:285–288 (June 1964).

(*6*) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL–147. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964).

(*7*) RIVERA, J. Dietary intakes and body burdens of cesium-137. Radiol Health Data 6:504–506 (September 1965).

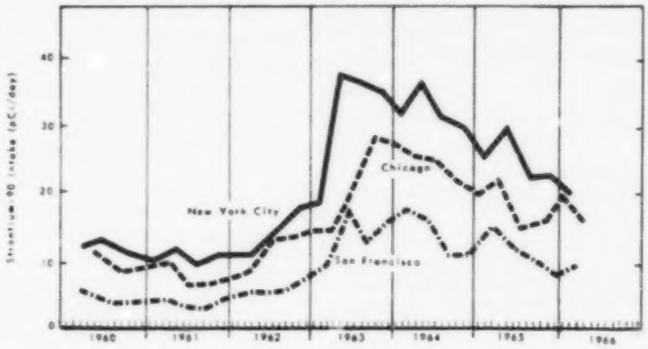

Figure 1. Daily intake of strontium-90 in Tri-City diet 1960–April 1966

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence [1] of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity, except when more complete analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

Program	Period reported	Last presented
Colorado River Basin Sampling Network	1962–1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Minnesota Surface Water Sampling Program	July–December 1965	July 1966
New York Water Sampling Program	June–December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Radiostrontium in Tap Water, HASL	May and July–November 1965	June 1966
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

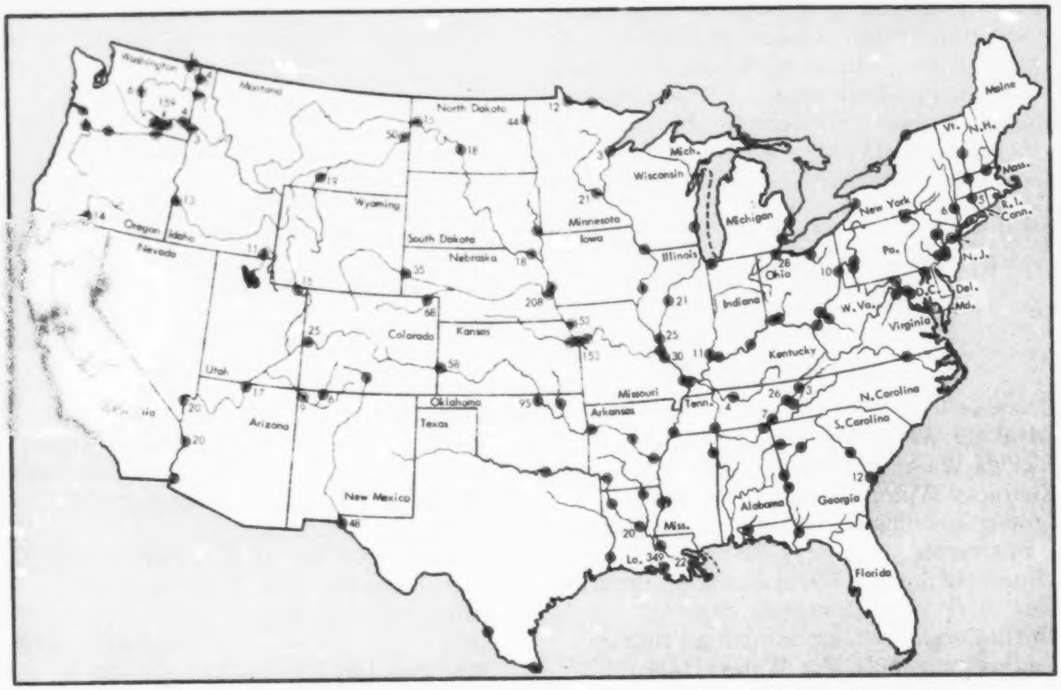
GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, JUNE 1966

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Table 1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or sus-


Washington
Montana
North Dakota
Minnesota
Wisconsin
Mich.
Michigan
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
New York
Pa.
N.J.
Del.
Md.
D.C.
Oregon
Idaho
Nevada
Wyoming
South Dakota
Nebraska
Iowa
Illinois
Indiana
Ohio
W. Va.
Virginia
Kentucky
Utah
Colorado
Kansas
Missouri
Tenn.
N. Carolina
S. Carolina
Arizona
New Mexico
Oklahoma
Texas
Arkansas
Miss.
Alabama
Georgia
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26
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4
7
12
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349
22

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, June 1966

pended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During May and June, the following stations showed alpha radioactivity in excess of 15 pCi/liter on dissolved or suspended solids: Platte River: Plattsmouth, Nebraska; North Platte River: Henry, Nebraska; and South Platte River: Julesburg, Colorado.

During June, the dissolved or suspended alpha radioactivity increased to more than 15 pCi/liter on the following stations: Arkansas River: Coolidge, Kansas; San Joaquin River: Vernalis, California; Atchafalaya River: Morgan City, Louisiana: and Mississippi River: Kansas, Missouri. Morgan City, Louisiana also showed a beta radioactivity on suspended solids of more than 150 pCi/liter.

REFERENCES:

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Table 1. Radioactivity in raw surface waters, June 1966

Station	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill N. Mex	2	4	6	0	1	1
Arkansas River:						
Coolidge, Kans	17	41	58	5	16	21
Ponca City, Okla	73	22	95	7	1	8
Atchafalaya River:						
Morgan City, La	335	14	349	121	1	122
Bear River:						
Preston, Idaho	1	10	11	0	2	2
Big Horn River:						
Hardin, Mont	2	17	19	<1	8	8
Chena River:						
Fairbanks, Alaska	10	2	12	2	<1	2
Clearwater River:						
Lewiston, Idaho	1	2	3	0	0	0
Clinch River:						
Clinton, Tenn	0	3	3	0	0	0
Kingston, Tenn [a]	9	17	26	<1	1	1
Colorado River:						
Loma, Colo	8	17	25	1	6	7
Page, Ariz	3	14	17	0	5	5
Boulder City, Nev	3	17	20	1	5	6
Parker Dam, Calif-Ariz	1	19	20	0	5	5
Columbia River:						
Wenatchee, Wash	1	5	6	0	0	0
Pasco, Wash [a]	82	77	159	0	<1	<1
Connecticut River:						
Enfield Dam, Conn	1	4	5	0	0	0
Cumberland River:						
Cheatham Lock, Tenn	0	4	4	0	0	0
Great Lakes:						
Duluth, Minn	0	3	3	0	0	0
Green River:						
Dutch John, Utah	<1	15	15	0	3	3
Hudson River:						
Poughkeepsie, N.Y	1	5	6	0	0	0
Illinois River:						
Peoria, Ill	4	17	21	1	3	4
Grafton, Ill	8	17	25	1	4	5
Klamath River:						
Keno, Ore	1	13	14	0	<1	<1
Maumee River:						
Toledo, Ohio	0	28	28	0	5	5
Mississippi River:						
St. Paul, Minn	3	18	21	0	2	2
E. St. Louis, Ill	17	13	30	4	3	7
New Orleans, La	10	12	22	3	2	5
Missouri River:						
Williston, N. Dak	3	12	15	1	3	4
Bismarck, N. Dak	1	17	18	0	3	3
Yankton, S. Dak	1	17	18	0	3	3
St. Joseph, Mo	30	22	52	6	3	9
Kansas City, Kans	132	21	153	37	4	41
North Platte River:						
Henry, Nebr	4	31	35	<1	17	17
Ohio River:						
Toronto, Ohio	2	8	10	0	0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	3	4	0	<1	<1
Platte River:						
Plattsmouth, Nebr	191	17	208	39	2	41
Rainy River:						
Baudette, Minn	2	10	12	0	0	0
Red River, North:						
Grand Forks, N. Dak	5	39	44	1	5	6
Red River, South:						
Alexandria, La	8	12	20	2	1	3
Rio Grande:						
El Paso, Tex	13	35	48	4	8	12
Sacramento River:						
Greens Landing, Calif	0	2	2	0	0	0
San Joaquin River:						
Vernalis, Calif	8	34	42	3	18	21
San Juan River:						
Shiprock, N. Mex	2	7	9	<1	2	2
Savannah River:						
Port Wentworth, Ga [a]	6	6	12	1	0	1
Snake River:						
Payette, Idaho	3	10	13	1	4	5
Wawawai, Wash	1	3	4	0	0	0
South Platte River:						
Julesburg, Colo	9	59	68	1	35	36
Tennessee River:						
Chattanooga, Tenn	0	7	7	0	0	0
Truckee River:						
Farad, Calif	0	1	1	0	0	0
Wabash River:						
New Harmony, Ind	1	10	11	0	2	2
Yellowstone River:						
Sidney, Mont	42	8	50	4	1	5
Maximum	335	77	349	121	35	122
Minimum	0	1	1	0	0	0

[a] Gross beta activity at this station may not be directly comparable to gross beta activity at other station because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides, common to all stations.

RADIOSTRONTIUM IN TAP WATER, NOVEMBER 1965-JUNE 1966[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium-90 concentration and cesium-137/strontium-90 ratios in New York City tap water for November 1965 through June 1966 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

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[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL 173. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151.

Table 1. Radiostrontium in New York City tap water November 1965-June 1966

Date	Strontium-90 [a] (pCi/liter)	Cesium-137/strontium-90
1965		
November	1.10	0.18
December	1.61	0.11
1966		
January	1.90	0.23
February	1.45	(b)
March	1.54	(b)
April	0.58	(b)
May	1.19	(b)
June	1.62	(b)

[a] Approximately 100 liters per sample; [b] No ratio reported

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E-38-01-16, Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York 14, New York.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. Title 42-Public Health, Chapter 1, Public Health Service, Department of Health, Education, and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154-5. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-June 1965	December 1965
May and July-November 1965	June 1966

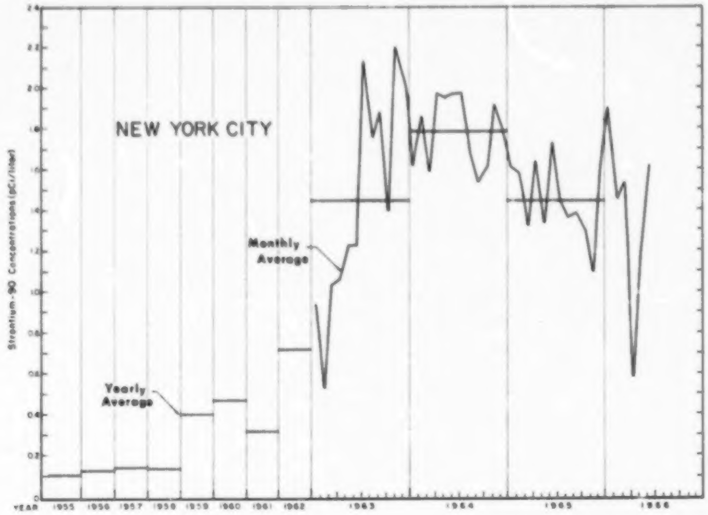


Figure 1. Strontium-90 concentrations in New York City tap water

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to those programs presented in this issue, the following program was previously covered in *Radiological Health Data and Reports*:

Network	Period reported	Last presented
HASL Fallout Network	July–December 1965	September 1966

175

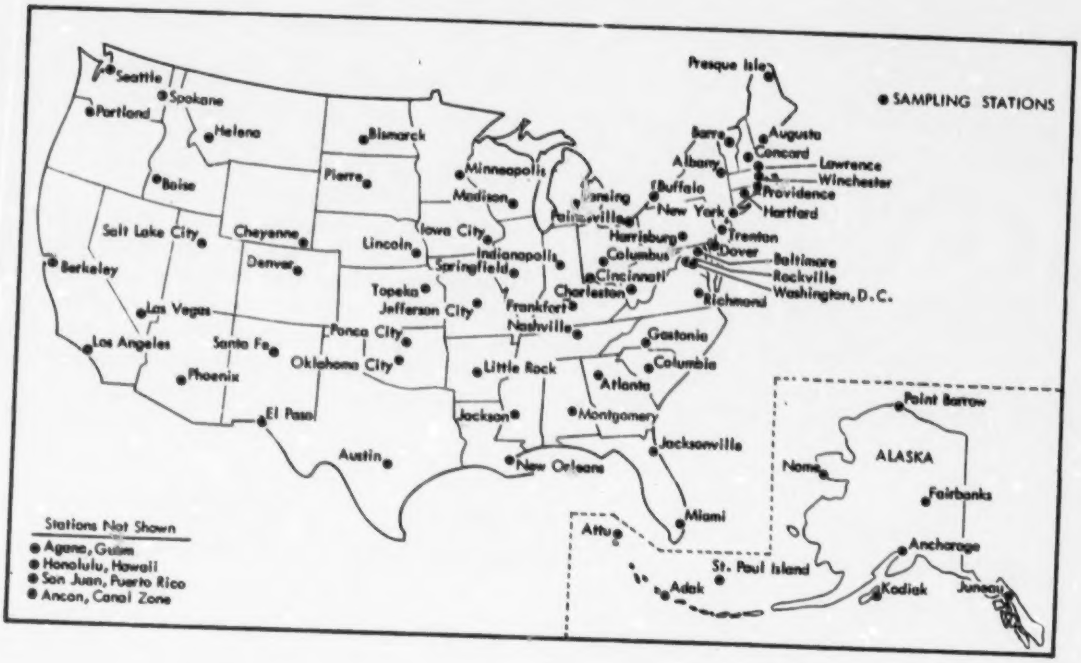
1. Radiation Surveillance Network
August 1966

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (2). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during August 1966. Time profiles of gross beta in air for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 308 air samples.


Seattle
Spokane
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Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Iowa City
Lincoln
Indianapolis
Springfield
Berkeley
Denver
Topeka
Jefferson City
Frankfort
Nashville
Las Vegas
Ponca City
Los Angeles
Santa Fe
Oklahoma City
Phoenix
Little Rock
El Paso
Jackson
Austin
New Orleans
Presque Isle
● SAMPLING STATIONS
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Lansing
Buffalo
Providence
Painesville
New York
Hartford
Harrisburg
Trenton
Columbus
Dover
Baltimore
Cincinnati
Rockville
Charleston
Washington, D.C.
Richmond
Gastonia
Columbia
Atlanta
Montgomery
Jacksonville
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Attu
Anchorage
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta activity in surface air and precipitation, August 1966

Station location		Number of samples		Air surveillance (gross beta activity, pCi/m³)			Last profile in *RHD&R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	28	8	0.12	<0.10	<0.10	Nov 66	57	<12
Alaska:	Adak	31		<0.10	<0.10	<0.10	June 66	(b)	
	Anchorage	23	10	<0.10	<0.10	<0.10	Mar 66	50	<10
	Attu Island	30		<0.10	<0.10	<0.10	July 66	(b)	
	Fairbanks	21	4	<0.10	<0.10	<0.10	Apr 66	13	<3
	Juneau	23	20	<0.10	<0.10	<0.10	July 65	234	<47
	Kodiak	6		<0.10	<0.10	<0.10	May 66	(b)	
	Nome	28		<0.10	<0.10	<0.10	Sept 66	(b)	
	Pt. Barrow	29		<0.10	<0.10	<0.10	Aug 66	(b)	
	St. Paul Islands	31		<0.10	<0.10	<0.10	Oct 66	(b)	
Ariz:	Phoenix	29		0.12	<0.10	<0.10	July 65	(b)	
Ark:	Little Rock	15	11	0.12	<0.10	<0.10	Dec 66	214	<43
Calif:	Berkeley	27	1	<0.10	<0.10	<0.10	May 66	3	<1
	Los Angeles	23		<0.10	<0.10	<0.10	Sept 66	(b)	
C.Z:	Ancon	18		<0.10	<0.10	<0.10	May 66	(b)	
Colo:	Denver	29	5	<0.10	<0.10	<0.10	May 66	28	<7
Conn:	Hartford	31	6	0.11	<0.10	<0.10	Apr 66	44	<9
Del:	Dover	22		0.12	<0.10	<0.10	Nov 66	(b)	
D.C:	Washington	28	4	0.12	<0.10	<0.10	Aug 66	40	<8
Fla:	Jacksonville	31	10	<0.10	<0.10	<0.10	Dec 66	186	<37
	Miami	29	9	<0.10	<0.10	<0.10	Apr 66	108	<22
Ga:	Atlanta	12	3	0.13	<0.10	<0.10	Oct 66	82	<16
Guam:	Agana	27		<0.10	<0.10	<0.10	Nov 66	(b)	
Hawaii:	Honolulu	31	1	<0.10	<0.10	<0.10	July 66	16	<3
Idaho:	Boise	28		0.13	<0.10	<0.10	July 66	(b)	
Ill:	Springfield	30	6	0.15	<0.10	<0.11	Aug 66	85	<17
Ind:	Indianapolis	28	3	0.17	<0.10	<0.11	Oct 66	35	<7
Iowa:	Iowa City	31	1	<0.10	<0.10	<0.10	May 66	5	<1
Kans:	Topeka	31	4	0.11	<0.10	<0.10	Mar 66	81	<16
Ky:	Frankfort	28	8	0.17	<0.10	<0.11	Aug 66	59	<12
La:	New Orleans	29	14	<0.10	<0.10	<0.10	Aug 66	259	<54
Maine:	Augusta	31	9	0.14	<0.10	<0.10	Sept 66	87	<17
	Presque Isle	25	8	0.15	<0.10	<0.10	May 66	47	<10
Md:	Baltimore	22	1	0.15	<0.10	<0.11	Apr 66	9	<2
	Rockville	15		0.11	<0.10	<0.10	July 66	(b)	
Mass:	Lawrence	31	6	0.13	<0.10	<0.10	Nov 66	30	<6
	Winchester	31	7	0.11	<0.10	<0.10	June 66	43	<9
Mich:	Lansing	31	7	0.14	<0.10	<0.10	July 66	54	<11
Minn:	Minneapolis	21	5	<0.10	<0.10	<0.10	Nov 66	128	<26
Miss:	Jackson	24	4	0.12	<0.10	<0.10	Sept 66	47	<9
Mo:	Jefferson City	31	6	0.13	<0.10	<0.10	Oct 66	31	<6
Mont:	Helena	29	5	0.14	<0.10	<0.11	June 66	12	<3
Nebr:	Lincoln	18	7	0.21	<0.10	<0.12	Oct 66	91	<18
Nev:	Las Vegas	28		0.12	<0.10	<0.10	Apr 66	(b)	
N.H:	Concord	20		0.13	<0.10	<0.11	Aug 66	(b)	
N.J:	Trenton	31	2	0.14	<0.10	<0.10	Sept 66	3	<1
N. Mex:	Santa Fe	25	9	<0.10	<0.10	<0.10	June 66	81	<16
N.Y:	Albany	22	7	<0.10	<0.10	<0.10	Oct 66	32	<6
	Buffalo	29		0.13	<0.10	<0.10	May 66	(b)	
	New York City	30		<0.10	<0.10	<0.10	June 66	(b)	
N.C:	Gastonia	31	10	0.13	<0.10	<0.10	May 66	45	<9
N. Dak:	Bismarck	31	6	0.12	<0.10	<0.10	Aug 66	109	<22
Ohio:	Cincinnati	17		<0.10	<0.10	<0.10	Nov 66	(b)	
	Columbus	30	8	0.28	<0.10	<0.15	Sept 66	109	<22
	Painesville	31	10	0.13	<0.10	<0.11	Apr 66	118	<24
Okla.	Oklahoma City	28	5	<0.10	<0.10	<0.10	July 66	125	<25
	Ponca City	24	9	<0.10	<0.10	<0.10	Apr 66	70	<14
Ore:	Portland	31	3	<0.10	<0.10	<0.10	Oct 66	16	<3
Pa:	Harrisburg	26	2	<0.10	<0.10	<0.10	Oct 66	30	<6
P.R:	San Juan	23	7	0.11	<0.10	<0.10	Sept 66	111	<22
R.I:	Providence	28	5	<0.10	<0.10	<0.10	July 66	66	<13
S.C:	Columbia	28	7	<0.10	<0.10	<0.10	June 66	133	<27
S. Dak:	Pierre	31	4	0.12	<0.10	<0.10	July 65	55	<11
Tenn:	Nashville	31	8	0.12	<0.10	<0.10	July 66	112	<23
Tex:	Austin	31	8	0.11	<0.10	<0.10	Nov 66	101	<21
	El Paso	29	6	<0.10	<0.10	<0.10	Aug 66	54	<11
Utah:	Salt Lake City	30	3	0.21	<0.10	<0.12	Sept 66	6	<1
Vt:	Barre	26	10	0.16	<0.10	<0.10	Dec 66	126	<26
Va:	Richmond	31	6	<0.10	<0.10	<0.10	Dec 66	33	<7
Wash:	Seattle	31	1	<0.10	<0.10	<0.10	Mar 66	3	1
	Spokane	29	1	0.12	<0.10	<0.10	Nov 66	1	<1
W. Va:	Charleston	31	9	0.14	<0.10	<0.10	June 66	68	<14
Wis:	Madison	27	4	0.11	<0.10	<0.10	Dec 66	98	<20
Wyo:	Cheyenne	31	8	0.14	<0.10	<0.10	Apr 66	62	<12
Network summary		1,987	351	0.28	<0.10	<0.10		70	<14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.

[b] No precipitation sample collected.

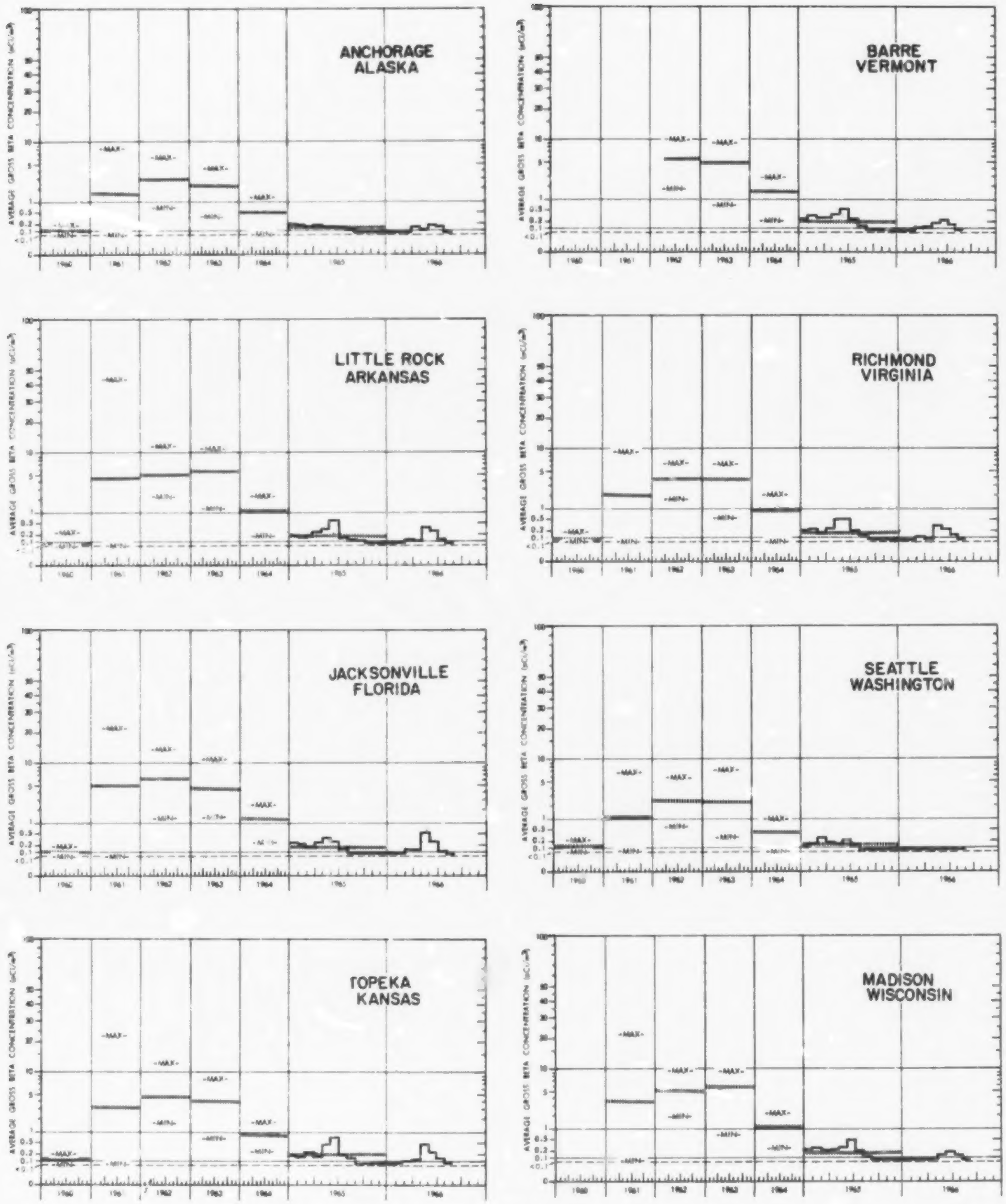

Figure 2. Monthly and yearly profiles of beta activity in air, Radiation Surveillance Network, 1960–August 1966

2. Canadian Air and Precipitation Monitoring Program, August 1966[1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the Radioactive Fallout Study Program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for August 1966 are presented in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, August 1966

Station	Air surveillance				Precipitation measurements	
	Number of samples	Activity, pCi/m³			Average concentrations (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	31	0.2	0.0	0.1	102	3.1
Coral Harbour	31	0.1	0.0	0.0	56	3.6
Edmonton	31	0.[illegible]	0.0	0.1	42	4.3
Ft. Churchill	31	0.1	0.0	0.1	70	1.2
Ft. William	31	0.2	0.0	0.1	14	1.6
Fredericton	31	0.2	0.0	0.1	40	1.5
Goose Bay	31	0.1	0.0	0.0	17	1.5
Halifax	31	0.1	0.0	0.1	28	1.9
Inuvik	31	0.1	0.0	0.1	31	0.8
Montreal	31	0.2	0.0	0.1	34	4.1
Moosonee	30	0.1	0.0	0.1	NS	NS
Ottawa	30	0.2	0.0	0.1	26	2.2
Quebec	30	0.2	0.0	0.1	30	3.9
Regina	31	0.2	0.0	0.1	40	2.3
Resolute	30	0.1	0.0	0.0	39	1.5
St. John's, Nfld	31	0.1	0.0	0.1	13	1.6
Saskatoon	31	0.2	0.0	0.1	44	2.1
Sault Ste. Marie	31	0.2	0.0	0.1	47	3.1
Toronto	31	0.2	0.0	0.1	27	1.6
Vancouver	31	0.1	0.0	0.1	37	1.1
Whitehorse	30	0.2	0.0	0.0	27	1.4
Windsor	31	0.2	0.0	0.1	24	3.0
Winnipeg	31	0.2	0.0	0.1	49	5.1
Yellowknife	30	0.2	0.0	0.1	153	0.8
Network summary		0.2	0.0	0.1	43	2.3

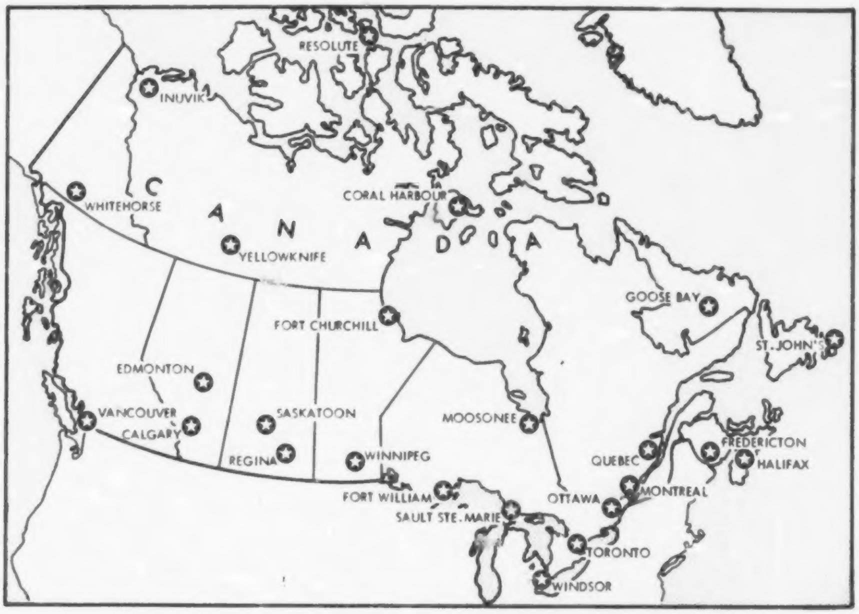
RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
YELLOWKNIFE
CORAL HARBOUR
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
SAULT STE. MARIE
OTTAWA
MONTREAL
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the September 1966 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Mexican Air Monitoring Program July and August 1966

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F., Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Deserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

Table 3. Mexican gross beta activity of airborne particulates, July 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	13	0.1	<0.1	0.1
Chihuahua	12	1.0	0.1	0.4
Ciudad Juárez	9	0.4	<0.1	0.3
Ensenada	13	0.4	0.1	0.2
Guadalajara	16	0.7	<0.1	0.1
Guaymas	3	0.1	0.1	0.1
La Paz	17	0.5	<0.1	0.2
Matamoros	7	0.4	<0.1	0.2
Mazatlán	15	0.5	<0.1	0.2
Mérida	12	0.6	<0.1	0.3
México, D.F.	15	1.1	<0.1	0.3
Nuevo Laredo	12	1.5	0.1	0.3
San Luis Potosí	12	0.4	<0.1	0.1
Tampico	13	0.5	<0.1	0.1
Torreón	9	1.3	0.1	0.3
Veracruz	13	1.7	<0.1	0.4

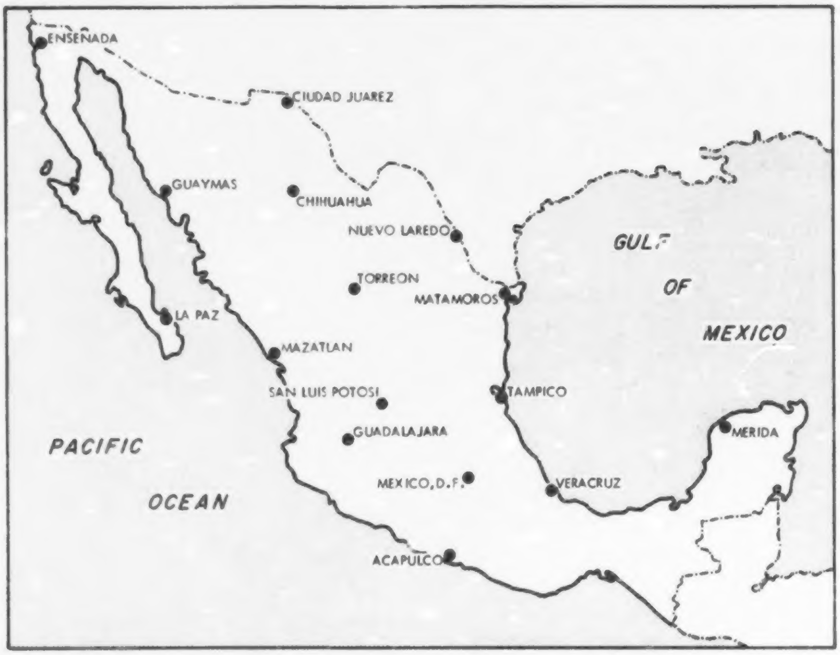

Figure 4. Fallout network sampling stations in Mexico

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta activity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average activity at each station (*8*).

The maximum, minimum, and average fission product beta concentrations in surface air during July and August 1966 are presented in tables 3 and 4.

Table 4. Mexican gross beta activity of airborne particulates, August 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	12	0.3	<0.1	0.1
Chihuahua	16	0.5	<0.1	0.1
Ciudad Juárez	15	0.4	<0.1	0.1
Ensenada	9	0.4	<0.1	0.1
Guadalajara	14	0.3	<0.1	0.1
Guaymas	3	0.6	0.1	0.4
La Paz	8	0.1	<0.1	<0.1
Matamoros	5	0.1	0.1	0.1
Mazatlán	10	0.2	<0.1	0.1
Mérida	15	0.3	<0.1	0.1
México, D.F.	9	0.6	<0.1	0.2
Nuevo Laredo	12	0.7	<0.1	0.2
San Luis Potosí	15	0.6	<0.1	0.1
Tampico	17	0.5	0.1	0.1
Torreón	19	0.9	<0.1	0.2
Veracruz	15	0.4	<0.1	0.2

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4. Pan American Air Sampling Program August 1966

Pan American Health Organization
and U.S. Public Health Service

Gross beta activity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station positions are shown in figure 5.

The August 1966 air monitoring results from the participating countries are given in table 5. Average and maximum levels for all stations except Bogota, Colombia, and Caracas, Venezuela, have decreased markedly from July levels. Bogota and Caracas increased very slightly from <0.10 pCi/m³ to <0.11 pCi/m³ and <0.12 pCi/m³, respectively.

None of the PAHO August samples were active enough to justify gamma scanning and, therefore, no fresh fission products were identified.

Table 5. PAHO gross beta activity in surface air August 1966

Station location	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	13	0.37	<0.10	<0.16
Chile: Santiago	22	0.55	<0.10	<0.22
Colombia: Bogota	22	0.27	<0.10	<0.11
Ecuador: Guayaquil	28	0.26	<0.10	<0.11
Jamaica: Kingston	23	<0.10	<0.10	<0.10
Peru: Lima	20	0.51	<0.10	<0.23
Venezuela: Caracas	20	0.26	<0.10	<0.12
West Indies: Trinidad	19	0.15	<0.10	<0.10
Pan American summary	167	0.55	<0.10	<0.14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more of the samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.

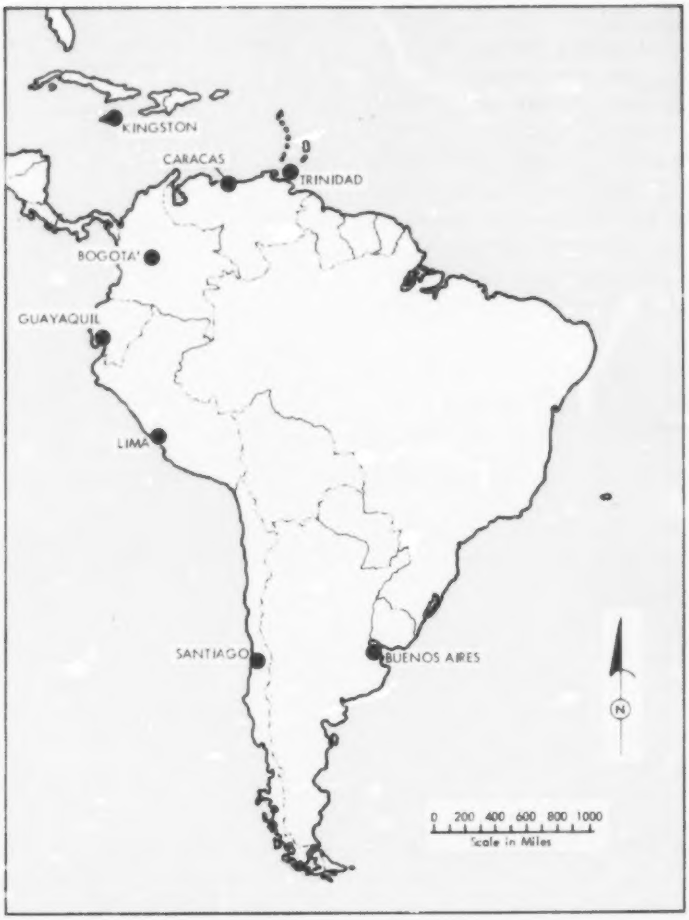

Figure 5. Pan American Air Sampling Program stations

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Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

STRONTIUM-90 IN HUMAN BONE, OCTOBER-DECEMBER 1965 [1]

Division of Radiological Health
Public Health Service

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium-90 in measurable amounts has been present in the global environment for more than a decade and major calcium accretion ceases by age 17 or 18, persons over 25 years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium-90 content to be low and age-independent (*1*).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available for older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for comparison of results with British data have not been successful.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Division of Radiological Health, at Winchester, Massachusetts. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by TBP extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To maintain analytical accuracy, pools of simulated "spiked" bone ash are analyzed in replicate on a continuing basis, and cross-checks with outside laboratories are conducted periodically.

The results of laboratory analyses for strontium-90 in individual bones from persons dying during the last quarter of 1965 are presented in table 1 in order of increasing age within each sampling region. The sampling regions have been defined in an earlier report (*5*). The data are reported as picocuries of strontium-90 per gram of ash (the primary determination), per gram of calcium (for comparision with other data and for purposes of model development), and per gram of bone (as a rough indication of

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[1] Period during which death of the donor occurred.

Table 1. Strontium-90 in human bone, deaths during October–December 1965

Location of sample by region and State	Sex	Bone type [a]	Age at death [b] (years)	Strontium-90, pCi/g of:			
				Ash	2 σ error	Calcium	Bone
Northeast:							
N.Y.	M	V	0 (7 mo)	1.07	0.15	3.06	0.08
Mass.	F	V	2	1.65	0.17	4.64	0.16
N.Y.	M	V	3	1.42	0.15	3.68	0.20
N.J.	M	V	3	0.97	0.10	2.69	0.09
N.Y.	M	V	4	1.15	0.17	3.21	0.07
N.Y.	F	V	5	0.82	0.08	2.14	0.09
Mass.	M	V	6	1.26	0.11	3.52	0.10
N.Y.	M	V	7	0.96	0.10	2.62	0.11
N.Y.	F	V	8	0.79	0.11	2.25	0.05
Mass.	M	V	9	0.87	0.07	2.29	0.08
Mass.	F	V	12	0.93	0.07	2.62	0.08
Mass.	F	V	13	1.90	0.11	5.77	0.18
Mass.	M	V	15	1.26	0.08	3.44	0.13
N.Y.	M	V	16	1.22	0.08	3.12	0.14
Mass.	M	V	19	0.68	0.07	1.74	0.10
Mass.	M	V	19	0.87	0.08	1.94	0.15
Mass.	M	V	19	0.93	0.09	2.32	0.15
Vt.	M	V	20	0.85	0.06	2.18	0.13
Mass.	M	V	20	1.09	0.07	2.82	0.15
Mass.	M	V	24	1.07	0.10	2.75	0.15
N.Y.	F	V	24	0.67	0.06	1.73	0.08
Southeast:							
Md.	M	V	7	0.88	0.11	2.45	0.09
Ky.	M	V	8	1.09	0.14	2.99	0.10
Md.	M	V	17	0.85	0.08	2.21	0.13
Md.	M	V	19	1.00	0.07	2.63	0.13
Ky.	F	V	19	0.80	0.08	2.15	0.10
Ky.	M	V	22	1.08	0.09	2.77	0.15
Central:							
Ohio	M	V	0 (5 mo)	1.69	0.20	4.92	0.13
Ohio	F	V	0 (9 mo)	2.31	0.24	6.61	0.18
Ohio	M	V	1	1.46	0.16	4.00	0.14
Ohio	M	V	2	1.59	0.14	4.34	0.15
Ohio	F	V	2	1.21	0.15	3.38	0.11
Ohio	F	V	3	1.37	0.14	3.81	0.13
Minn.	F	V	5	0.89	0.11	2.43	0.08
Minn.	F	V	5	2.18	0.16	5.90	0.18
Ohio	M	V	6	0.75	0.10	2.04	0.06
Ohio	M	V	6	0.75	0.07	2.11	0.07
Ohio	F	V	6	0.69	0.07	1.73	0.18
Ohio	M	V	7	1.11	0.12	2.88	0.19
Minn.	M	V	9	1.05	0.15	2.92	0.08
Minn.	M	V	11	0.84	0.09	2.29	0.07
Ohio	M	V	13	1.10	0.09	2.80	0.25
Ohio	F	V	13	0.87	0.07	2.36	0.09
Ohio	M	V	14	1.07	0.09	2.56	0.19
Minn.	M	V	16	0.81	0.09	2.14	0.09
Minn.	F	V	17	0.53	0.07	1.37	0.08
Minn.	F	V	18	0.60	0.07	1.54	0.08
Ohio	M	V	20	1.04	0.10	2.60	0.20
Ohio	M	V	21	0.75	0.10	1.90	0.13
Ohio	M	V	22	0.77	0.07	2.00	0.16
Ohio	M	V	22	0.77	0.09	1.94	0.16
Ohio	M	V	23	0.52	0.07	1.31	0.10
Ohio	M	V	23	0.53	0.06	1.36	0.09
Ohio	F	V	23	0.41	0.06	1.01	0.08
Ohio	M	V	23	0.82	0.07	2.08	0.14
Ohio	M	V	24	0.86	0.09	2.17	0.14
Ohio	M	V	25	0.89	0.08	2.41	0.08
Delta:							
La.	M	V	1	2.07	0.16	5.69	0.22
La.	M	V	1	1.02	0.12	2.76	0.11
La.	F	V, S	1	1.27	0.15	3.60	0.09
La.	F	V, S	3	1.89	0.15	5.19	0.17
La.	M	V	10	1.07	0.14	2.94	0.10
La.	F	V, R	17	0.43	0.05	1.32	0.09
La.	F	V, R	17	0.89	0.07	2.33	0.11
La.	M	R	23	0.59	0.05	1.43	0.19
La.	M	V, R	24	1.16	0.09	3.02	0.19
Southwest:							
Calif.	M	V, R	1	1.69	0.13	4.81	0.11

[a] Type of bone: V, vertebrae
R, rib
S, sternum

[b] Age given as of last birthday prior to death.

dose). Two-sigma counting errors are reported for the ash concentration. Table 2 summarizes all available data from 1961 through 1965.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–4*).

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
Deaths through 1964	April 1966
First quarter 1965	June 1966
Second quarter 1965	September 1966
Third quarter 1965	October 1966

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(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64-1 (April 1964) Winchester, Mass. 01890.

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone. Radiol Health Data 5:620–628 (December 1964).

(*5*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Strontium-90 in human bone, October 1964–March 1965. Radiol Health Data 6:397–401 (July 1965).

Table 2. Strontium-90 in human bone samples for 5-year age groups, 1961–1965

Age group [a]	Year of death [b]	Number	Strontium-90/calcium (pCi/g)		
			Mean [c]	Minimum	Maximum
0–4 years	1961	3	2.7	1.8	3.4
	1962	50	3.3	0.8	9.7
	1963	44	4.5	1.0	13.0
	1964	67	4.4	1.0	8.7
	1965	68	3.9	0.7	8.9
5–9 years	1961	1	2.7	—	—
	1962	33	2.7	1.0	9.4
	1963	43	3.9	1.8	9.1
	1964	64	3.6	1.2	7.0
	1965	47	2.9	1.3	6.4
10–14 years	1961	4	1.8	1.2	2.8
	1962	28	2.1	0.8	3.5
	1963	47	2.9	1.1	9.0
	1964	56	3.1	0.9	5.7
	1965	38	2.8	1.1	5.8
15–19 years	1961	0	—	—	—
	1962	31	2.2	0.9	4.6
	1963	73	2.6	1.0	7.0
	1964	58	2.9	1.2	8.0
	1965	56	2.3	1.3	4.7
20–24 years	1961	0	—	—	—
	1962	29	1.8	0.9	3.5
	1963	61	2.2	0.9	5.0
	1964	52	2.2	0.8	4.3
	1965	45	2.0	1.0	3.0

[a] Age given as of last birthday prior to death or surgery; ages greater than 24 years not included.

[b] Or surgical procedure.

[c] Mean values given in this table for the various years within each age group may not be directly comparable because of variations in sampling locations from year to year; however, the data are given as a summary of presently available results.

STRONTIUM-90 IN HUMAN VERTEBRAE 1965 RESULTS [1]

Health & Safety Laboratory
Atomic Energy Commission

One of the problems under investigation at the Health and Safety Laboratory (HASL) is the relation between diet levels of strontium-90 and bone strontium-90 concentrations. Since 1960, quarterly analyses of foods and estimates of the dietary intake of strontium-90 at New York City, Chicago, and San Francisco have been made at HASL (*1*). Measurements of the strontium-90 content of human bone from residents of these same cities have been made at HASL since 1960 (*2*). Results of the analyses of specimens obtained during 1965 are listed in tables 1 through 3. Average strontium-90/calcium ratios of children's vertebrae from New York City and San Francisco, with respect to age, are shown in figure 1.

It can readily be seen from figure 1 that the variation of strontium-90 concentrations in children's bones with age were similar in New York City and in San Francisco, although the New York City levels were higher. As in previous years, highest strontium-90 concentrations

Table 1. Strontium-90/calcium ratios in human vertebrae of New York City children, 1965

Age, years	Strontium-90/calcium ratios (pCi/g)	Number of specimens	Average (pCi/g)
<1 mo	[a] 2.79(6)	6	2.79
1 mo–1 yr	4.97(5)	5	4.97
1–2	7.02(3)	3	7.02
2–3	7.17(2)	2	7.17
3–4	9.10 6.82 6.00(2) 6.01(2)	6	6.66
4–5	4.26 3.97	2	4.12
5–6	3.39 3.95 4.17	3	3.84
6–7	4.86 1.72	2	3.29
7–8	3.05	1	3.05
8–9	4.44	1	4.44
9–10	3.57 2.28 3.87	3	3.24
10–11	2.87 3.20 2.96 3.61	4	3.16
11–12	3.37 1.23 3.93	3	2.84
12–13	5.17	1	5.17
13–14	2.51	1	2.51
14–15	3.76	1	3.76
15–16	3.71 4.03 5.36 4.27	4	4.34
16–17	3.36 4.45	2	3.91
17–18	2.33 3.55	2	2.94
18–19	2.71 1.82 3.44 3.89 2.92 3.12 3.03	7	2.99
19–20	3.66 2.57 1.89	3	2.71

[a] Parentheses indicate number of individual samples in the composite.

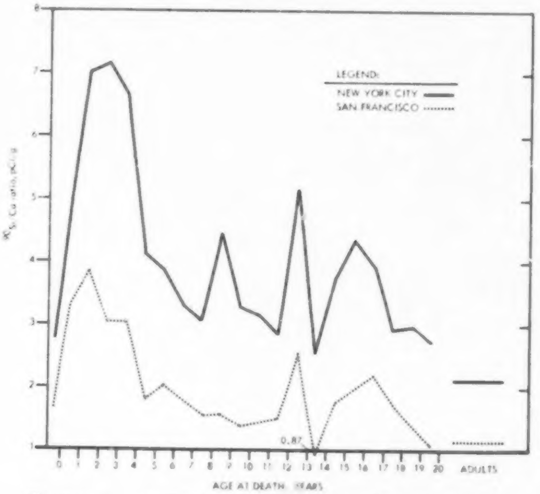

Figure 1. Strontium-90/calcium ratios in human vertebrae, 1965

were found in the bones of young children and infants, lowest strontium–90 concentrations were found in the bones of adults, and there was some indication of an increase in strontium–90 concentrations in bone during early adolescence. On the average, strontium–90/calcium ratios in bones from children who lived in New York City were twice as high as those from children who lived in San Francisco prior to death. This finding is consistent with the observations of the Tri-City Diet studies which indicate that the daily intake of strontium–90 in New York City has consistently been about twice as high as the daily intake of strontium–90 in San Francisco.

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[1] Material authored by Mr. J. Rivera, from Fallout Quarterly Summary Report, HASL–172, July 1, 1966. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151.

The results of the analyses of vertebrae from adults are listed in table 3. As in previous years, and consistent with the results of the Tri-City Diet studies, highest strontium–90/calcium ratios were found in the specimens from New

Table 2. Strontium-90/calcium ratios in human vertebrae of San Francisco children, 1965

Age, years	Strontium-90/calcium ratios (pCi/g)	Number of specimens	Average (pCi/g)
<1 mo	[a] 1.38 (4) 1.45 (4) 1.61 (6) 1.23 (6) 2.37 (6)	23	1.64
1 mo–1 yr	4.42 5.60 1.44 3.14 (10)	13	3.30
1–2	3.50 (2) 4.20 (3) 3.33	6	3.82
2–3	3.07	1	3.07
3–4	1.01 4.82 3.22	3	3.02
4–5	1.60 1.81 2.07 1.89 1.80	5	1.83
5–6	0.55 2.57 3.01	3	2.04
6–7	—	—	—
7–8	1.53	1	1.53
8–9	1.54	1	1.54
9–10	1.40 2.33 0.45	3	1.39
10–11	—	—	—
11–12	0.48 2.51	2	1.50
12–13	2.56	1	2.56
13–14	0.87	1	0.87
14–15	1.79	1	1.79
15–16	—	—	—
16–17	2.20	1	2.20
17–18	1.78	1	1.78
18–19	—	—	—
19–20	0.71 0.89 1.62 1.09	4	1.09

[a] Parentheses indicate number of individual samples in the composite.

Table 3. Strontium-90/calcium ratios in human vertebrae of adults, 1965

City	Age range (years)	Strontium-90/calcium ratios (pCi/g)	Number of specimens	Average (pCi/g)
New York	20–30	1.69 1.87 1.81 2.98 1.70 1.33	6	1.90
	30–60	2.33 2.34 2.64 2.04 1.84 2.50	6	2.28
	>60	1.70 2.72 2.18 2.37	4	2.24
	>20	—	16	2.13
Chicago	20–30	1.11 2.85 1.84	3	1.93
	30–60	1.26 1.81 1.06 0.84 0.42 0.57 1.69 2.08 1.56 0.67 0.70 0.67 1.77	13	1.16
	>60	—	—	—
	>20	—	16	1.30
San Francisco	20–30	0.59 1.72 0.94 1.13	4	1.10
	30–60	1.22 1.31 0.93 2.14 1.04 0.71 0.74 0.38 1.19 0.96 0.66 1.46 1.42 0.45 0.60 0.74 1.93 1.28 1.21 2.54 2.24	21	1.2
	>60	0.39 1.11 0.68 1.57 1.49	5	1.05
	>20	—	30	1.16

York City, lowest values were found in bones from San Francisco, and intermediate values were found in bones from Chicago. As with children's bones, the strontium-90 concentrations of adult vertebrae from New York City residents were about twice as high as those from San Francisco residents.

It has been suggested that the concentrations of strontium-90 in human bone are described more correctly by a log-normal distribution, than by a normal distribution (*3*). A study is being made of the distribution of strontium-90/calcium ratios found in the relatively large and homogeneous groups of San Francisco adult samples. It appears at present that both distributions adequately describe the observed data; but further statistical analysis, now in progress, will be needed before it can be decided whether or not one distribution function describes the observed data significantly better than the other distribution.

In an earlier report (*2*), two formulas were given that could be used to predict the strontium-90/calcium ratios (X_n) of infant and adult bone, from information on the average diet strontium-90/calcium ratio (Z) during the year, and the average level of strontium-90/calcium in bone (X_{n-1}) at the beginning of the year. The formulas were:

for infants: $X_n = 0.2\ Z$

for adults: $X_n = 0.9\ X_{n-1} + 0.02\ Z$

These equations were used to predict the levels of strontium-90 in infant and adult bone during 1965. The predicted and observed values are shown in table 4.

Table 4. Predicted and observed strontium-90/calcium ratios in bone, 1965

City	Strontium-90/calcium, pCi/g					
	Infants			Adults		
	Z	X_n		X_{n-1}	X_n	
		Predicted	Observed		Predicted	Observed
New York City	24	4.8	5.6	2.0	2.0	2.1
Chicago	20	4.0	—	1.4	1.7	1.3
San Francisco	12	2.4	3.3	1.2	1.3	1.2

It appears that the formulas are reasonably valid for predicting strontium-90/calcium ratios in infant and adult bone. It should be noted, however, that the results of the analyses of bones from a single year cannot be used to unequivocally test the validity of a prediction model for strontium-90 levels in bone, because of the small number of bone samples usually available for analysis in 1 year, and the consequent uncertainty in the estimated mean strontium-90 levels for each age. An example of the influence of these uncertainties is seen in the results of the application of the equation for adults. Clearly the strontium-90/calcium levels in adult bone must increase so long as the level in bone is less than about one-fourth the strontium-90/calcium level in the diet. The observed average values for adult vertebrae for Chicago and San Francisco, however were not higher in 1965 than in 1964. This, no doubt, must be due to the uncertainties in the estimates of the mean levels in 1964 and 1965.

The direct determination of the parameters governing strontium metabolism in children is difficult, if not impossible. From continuing measurements of the strontium-90 content of human bone and diets, it may be possible to make some quantitative inferences as to the variation of strontium metabolism with age. Data obtained during 1965 will be combined with previously obtained results to give new provisional estimates of the factors influencing this variation (*4*).

REFERENCES

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(*2*) RIVERA, J., and J. H. HARLEY. The HASL bone program, 1961-1964. Atomic Energy Commission Report No. HASL-163 (August 16, 1965).

(*3*) MAREI, A. N., V. A. KNIZHNIKOV, E. I. YARTSEV, and E. I. MOISEENKO. Strontium-90 content in bone tissue of the population of the Soviet Union in 1959-1963. State Committee on Use of Atomic Energy USSR, Atomizdat, Moscow (1964).

(*4*) RIVERA, J. Predicting strontium-90 concentrations in human bone. Presented at an International Symposium on Some Aspects of Strontium Metabolism, held at Annan, Scotland (May 5-6, 1966).

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for the Brookhaven National Laboratory and the Rocky Flats Plant.

1. Brookhaven National Laboratory January–June 1966 [2]

Associated Universities, Inc.
Upton, New York

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: (1) by discharge of coolant air from the graphite research reactor, (2) by radiation from an ecology forest gamma source, and (3) by the discharge of low-level radioactive liquid wastes into a small stream that forms one of the headwaters of the Peconic River (figure 1).

Area monitoring

The radioactivity in the discharge coolant air is almost entirely due to argon–41, a beta-gamma emitter. Because exposure to argon–41 is due to external gamma, the monitoring is performed by measuring the exposure rate in milliroentgens per week (mR/wk) rather than the concentration in air.

Late in 1961, a 10,000-curie cesium–137 gamma source was installed in the ecology forest about 800 meters equidistant from the north and east boundaries. The radiation levels resulting from the research reactor effluent and the ecology forest source are monitored continuously by four stations located along the site perimeter (figure 2).

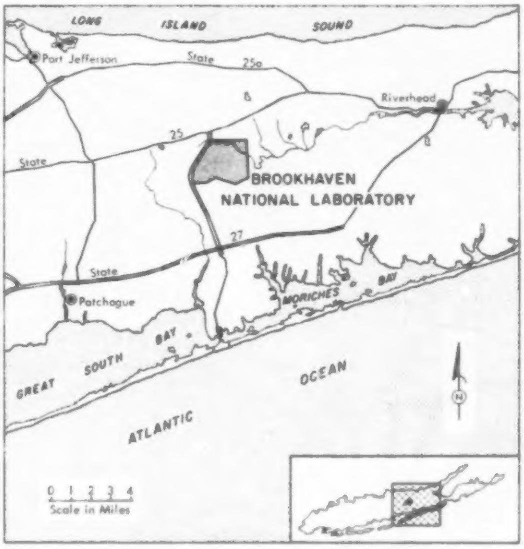

Figure 1. Brookhaven National Laboratory and surrounding area

Radiation levels at the northeast perimeter are somewhat greater than at other monitoring stations due to the ecology forest source. However, the radiation levels at this location are within the established AEC standard which is 0.5 rem/yr for individuals in the general population. The average weekly radiation levels at the Brookhaven National Laboratory site perimeter, due to laboratory operations, are given in

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[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contain essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[2] Summarized from "Effects of Brookhaven National Laboratory on Environmental Levels of Radioactivity during the First Half of 1966," Associated Universities, Inc., Upton, New York.

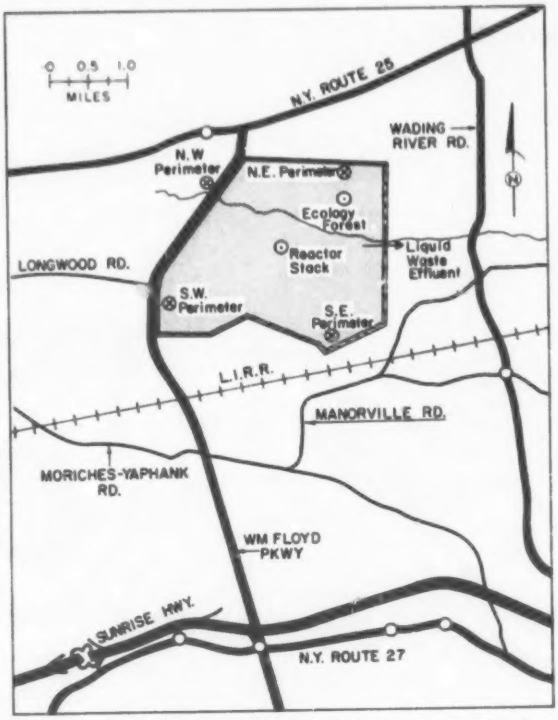

Figure 2. Brookhaven National Laboratory monitoring station locations

Table 1. External gamma levels at BNL site perimeter January–June 1966

Period	Average exposure rates, mR/wk			
	North-west perimeter	South-west perimeter	South-east perimeter	North-east perimeter
Gamma exposure from laboratory operations:				
First half 1966	0.18	0.20	0.46	2.32
January	0.04	0.18	1.07	1.56
February	0.16	0.04	0.40	1.80
March	0.26	0.09	0.25	1.95
April	0.09	0.08	0.29	1.92
May	0.31	0.43	0.54	2.60
June	0.18	0.39	0.28	3.80
Average undisturbed background	1.91	1.72	1.90	1.95

table 1. Values of radiation background levels undisturbed by laboratory operations have also been included in table 1 for purposes of comparison.

Water monitoring

The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where it is discharged to the small stream. The values of concentration and activity in the stream where it leaves the BNL site are computed on the basis of continuous measurements of the stream flow rate. The gross concentration and amount of radioactivity in the laboratory's liquid waste effluent, as it leaves the site, are shown in table 2.

Analysis of composite samples of the effluent has shown that, on the average, no more than 20 percent of the activity consists of strontium-90 and that no appreciable amounts of radioactive iodine or radium and other bone-seeking isotopes are present. The average gross concentration for the 6-month period, 38 picocuries per liter, was less than the established AEC standard for concentrations in effluents to unrestricted areas.

Table 2. Gross activity in BNL liquid waste effluent at site boundary, January–June 1966

Period	Average concentration (pCi/liter)	Total activity discharged, mCi
First half 1966	38	20.6
January	30	2.2
February	49	4.3
March	38	2.9
April	31	2.9
May	32	3.1
June	48	5.3

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1961	June 1962
January–June 1962	January 1963
July 1962–June 1963	February 1964
July 1963–June 1964	December 1964
July–December 1964	June 1965
January–June 1965	December 1965
July–December 1965	June 1966

2. Rocky Flats Plant January–June 1966[3]

Dow Chemical Company
Golden, Colorado

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location relative to population centers is shown in figure 3. To

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[3] Summarized from "Environmental Survey, January–June 1966," Dow Chemical Company, Rocky Flats Division, Golden, Colorado.

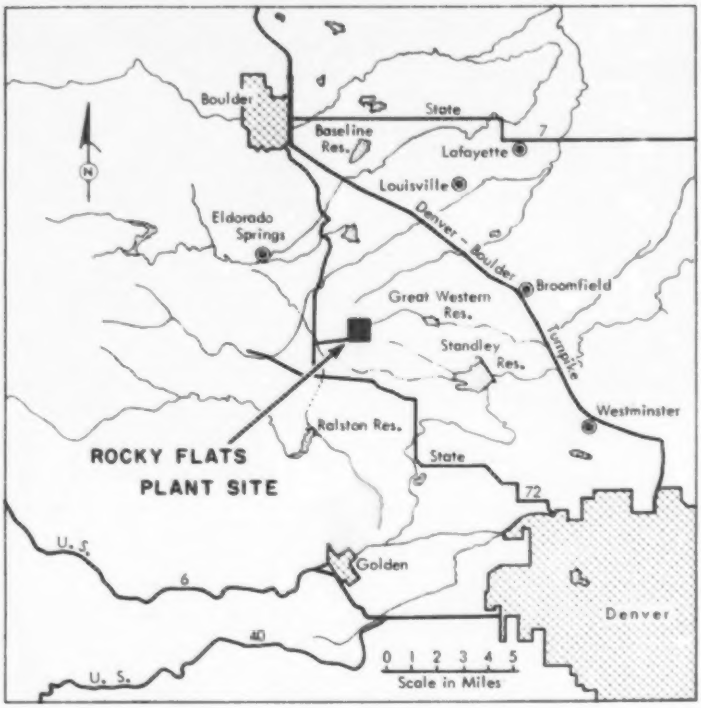
Boulder
State
7
Baseline Res.
Lafayette
Louisville
Eldorado Springs
Denver – Boulder Turnpike
Broomfield
Great Western Res.
Standley Res.
Westminster
Ralston Res.
ROCKY FLATS PLANT SITE
State
72
U. S.
6
Golden
Denver
40
U. S.
0 1 2 3 4 5
Scale in Miles
N

Figure 3. Location of the Rocky Flats Plant environment Denver, Colorado

assure properly controlled release of radioactive materials to the environment, periodic samples of water, air, and vegetation are analyzed for gross alpha activity. The most abundant radioactive material involved in the process is plutonium.

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized Front Range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

Air

Continuous 24-hour air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The monthly average long-lived gross alpha activities shown in table 3 are believed to result from naturally occurring materials. All values are less than the AEC standard of 0.04 pCi/m^3 for mixtures of unidentified nuclides.

Table 3. Long-lived gross alpha activity in airborne particulates collected in the vicinity of RFP, January–June 1966

Period	Average alpha concentration (pCi/m^3)
January	0.006
February	<0.006
March	0.007
April	0.009
May	0.010
June	<0.006

Water

Regular water samples were obtained once every 2 weeks except during the winter months from 4 reservoirs in the area of the Rocky Flats Plant. The results of alpha activity analyses performed on these samples are given in table 4. The analytical results for water samples obtained during June from outlying streams and lakes and for the 1966 vegetation sampling program will be reported in a subsequent issue of *Radiological Health Data and Reports.*

Table 4. Alpha activity in water collected from reservoirs in the vicinity of RFP, January–June 1966

Reservoir	Number of samples	Average alpha concentration (pCi/liter)
Great Western	8	2.0
Standley	8	1.2
Baseline	8	1.7
Ralston	8	2.8

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July 1962–June 1963	February 1964
July 1963–June 1964	December 1964
July–December 1964	June 1965
January–June 1965	December 1965
July–December 1965	June 1966

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, NOVEMBER 1966

During November 1966, three U.S. nuclear tests conducted underground at the Nevada Test Site, were announced by the U.S. Atomic Energy Commission.

These tests conducted on November 5, 11, and 18 were of low yield (less than 20 kilotons TNT equivalent).

Annual Subject Index

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- Alaska
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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished in reference card format for the convenience of readers who may wish to clip them for their files.

SUMMARY OF CESIUM-137 AND STRONTIUM-90 CONCENTRATIONS REPORTED IN CERTAIN ALASKAN POPULATIONS AND FOODSTUFFS, 1961-1966. *R. P. Chandler* and *D. R. Snavely. Radiological Health Data and Reports, Vol. 7, December 1966, pp. 691-696.*

Published data on cesium-137 and strontium-90 concentrations in certain Alaskan populations and foodstuffs are reviewed and summarized along with food consumption data. Where possible, concentrations in the diet and those found in people are compared to FRC guidelines. The seasonal and yearly trends of cesium-137 and strontium-90 concentrations in the diet of Alaskan populations and in people are discussed.

KEY WORDS: Alaska, body burdens, cesium-137, Eskimos, strontium-90.

CESIUM-137 BODY BURDENS IN ALASKAN MEN, SPRING 1966. *D. Fitzpatrick, J. L. Russell, O. G. Briscoe,* and *C. R. Calvert. Radiological Health Data and Reports, Vol. 7, December 1966, pp. 691-696.*

The cesium-137 body burdens of caribou-eating Alaskan men continue to be elevated, although in general the average body burdens are decreasing, compared to those observed in 1965. Elevated cesium-137 body burdens are well correlated with caribou (reindeer) consumption, and non-caribou eaters exhibit cesium-137 body burdens similar to residents in the conterminous United States. Of the 418 adult males counted during the spring of 1966, none was observed to have a cesium-137 body burden in excess of the guidance of the Federal Radiation Council (3,000 nCi), although one subject was found with a body burden of 80 percent (2,400 nCi) of this level.

KEY WORDS: Alaska, body burden, caribou, cesium-137, deposition, diet, fallout.

ERRATUM

A statement appearing in the data "Iodine-131 in Bovine Thyroids, July-December 1965" (Radiol Health Data Rep 7:601-604, October 1966) should be amended. The statement on page 601 beginning "The influx of fallout" should read "The continued influx of iodine-131 fallout following the mainland China atmospheric nuclear detonation of May 14, 1965, was observed to be generally low ($<$150 pCi/g thyroid) during July 1965, declining to barely detectable levels in late July 1965. Considerably higher values were seen in several of the individual thyroids collected during June 1965 (*2*)."

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Iodine-131 in bovine thyroids, January-June 1965. Radiol Health Data Rep 7:49-55 (January 1966).

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